SCHOOL OF CIVIL ENGINEERING

JOINT HIGHWAY RESEARCH PROJECT

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METHODOLOGY FOR EVALUATING THE IMPACTS OF ENERGY, NATIONAL ECONOMY, AND PUBLIC POLICIES ON STATE HIGHWAY FINANCING AND PERFORMANCE

F. L. Mannering

PURDUE UNIVERSITY
INDIANA STATE HIGHWAY COMMISSION

Final Report

METHODOLOGY FOR EVALUATING THE IMPACTS OF ENERGY, NATIONAL ECONOMY, AND PUBLIC POLICIES ON STATE HIGHWAY FINANCING AND PERFORMANCE

TO: Harold L. Michael, Director
Joint Highway Research Project

July 11, 1979

File: 3-4-6

FROM: Kumares C. Sinha, Research Engineer
Joint Highway Research Project

Project: C-36-73F

Attached is a Final Report by Mr. Fred L. Mannering, Graduate Instructor in Research on our staff, titled "Methodology for Evaluating the Impacts of Energy, National Economy, and Public Policies on State Highway Financing and Performance". Professor K. C. Sinha directed the research and guided preparation of the Final Report.

The Report describes the development of a computer model that can be utilized to analyze and estimate the complex interactions between the critical factors influencing state highway financing and their impact on highway system performance. The model was extensively tested and applied to the Indiana situation. The options considered in this study revealed that, although a general decline in highway performance can be expected, appropriate highway policy decisions can assure the sustenance of a tolerable level of highway performance well into the future.

The Report is presented as the Final Report on this Study for acceptance as fulfillment of its objectives.

Respectfully submitted,

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by

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Indiana State Highway Commission

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ABSTRACT

Mannering, Fred Laires. MSCE Purdue University, May 1979.
Methodology for Evaluating the Impacts of Energy, National Economy,and Public Policies on State Highway Financing and Performance.
Major Professor: Kumares C. Sinha.

Inflationary pressures, stabilizing road-use tax revenues, energy constraints, and recent national automotive policy decisions have created problems which have dramatically affected the highway financing process. The objective of this project was to develop a tool which can be utilized to analyze and estimate the complex interactions between the critical factors influencing state highway financing and their ultimate impact on highway performance, so that the results could enable legislators to make informed decisions regarding this issue. This objective was achieved by the development of a computer simulation model which was extensively tested and applied to the Indiana problem.

The computer model utilized the national energy and economic forecasts developed by Data Resources Inc. along with various assumptions regarding legislative options to project a probable range of Indiana highway performance. The results of the model application indicated that an overall deterioration in highway performance can be expected to continue in Indiana as the funds required to stabilize or improve highway performance are enormous. However, the extent of future highway performance deterioration can be regulated by new

taxing policies, revised highway performance criteria, and governmental promotion of car pooling, mass transit, and other factors that may effectively reduce future highway congestion. The options considered in this study revealed that, although a general decline in highway performance can be expected, appropriate highway policy decisions can assure the sustenance of a tolerable level of highway performance well into the future.

CHAPTER 1

INTRODUCTION

The present state highway financing process is confronted with a number of serious problems that have been aggravated by recent economic conditions and national policy decisions. On one hand the highway construction, operation, and maintenance costs have experienced rampant increases in recent years, as shown in Figure 1, while the amount of road-user tax revenues has remained the same or declined, as shown in Figure 2. At the same time, increasing proportions of the state highway budget are being consumed by non-capital recurring costs such as routine maintenance, highway patrol, safety, planning, research, administration, and debt service (1).

Such problems have led to the deferral of many needed highway improvement projects, and subsequently, the overall highway performance has suffered. Moreover, the long-term impacts that national and regional energy conservation efforts will have on the state highway financing process are not clearly understood.

It is clear that there is a definite need to examine possible legislative actions to substantially change the state revenue generating structure and/or tax rates in order to provide sufficient resources for highway construction, operation, and maintenance. The intent of the present research project is to provide a tool, in the

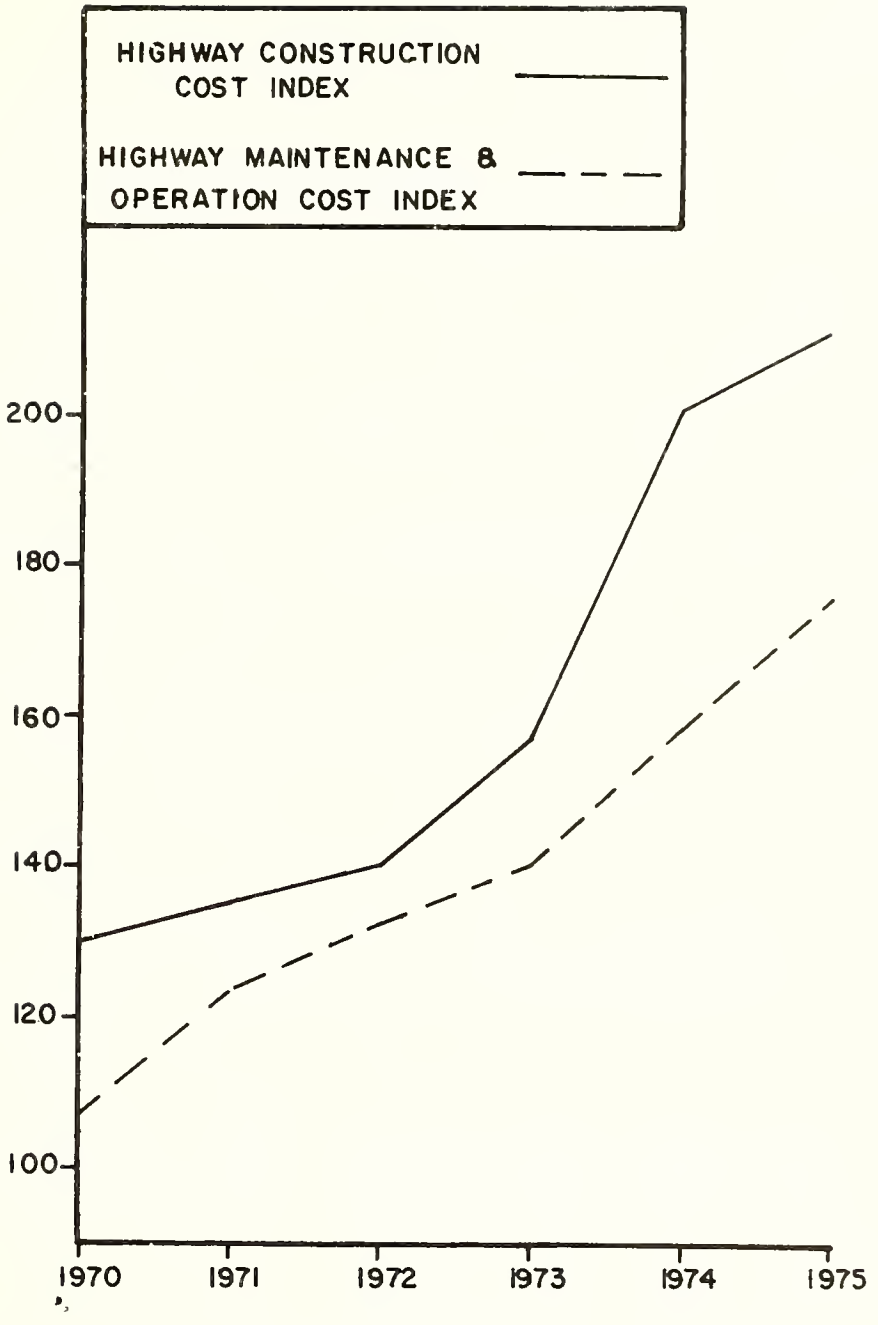

FIGURE 1. SUMMARY OF NATIONAL HIGHWAY CONSTRUCTION AND HIGHWAY MAINTENANCE & OPERATION COST INDICES

SOURCE: REFERENCE 1.

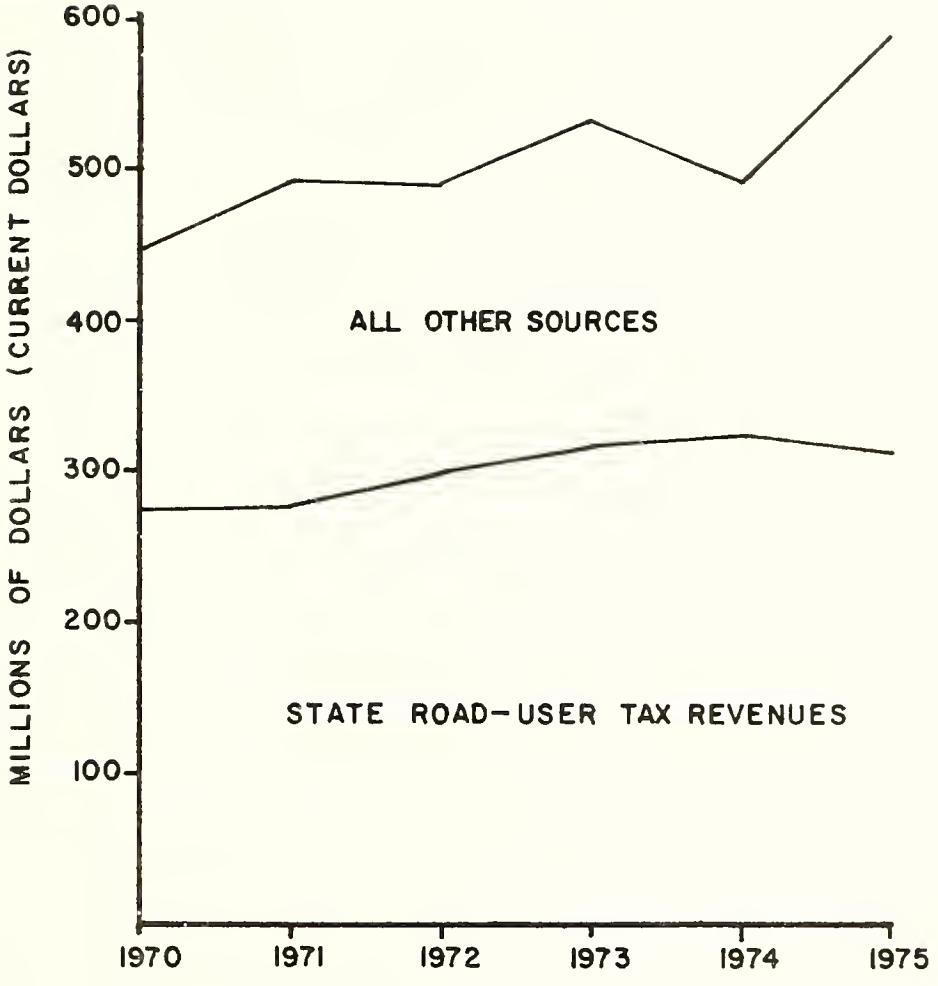

FIGURE 2. TOTAL HIGHWAY REVENUES BY SOURCE IN INDIANA (1970–1975)

SOURCE: REFERENCE 1.

form of a computer model, to systematically evaluate the impacts that various proposed highway related legislative decisions may have on highway performance in Indiana.

Two recent studies investigated the problem of state highway financing in Indiana (2,3). The first study dealt exclusively with revenue generation (2) while the other study projected estimates of "highway needs" which were determined subjectively only on an aggregated basis (3). Most studies performed in connection with state highway financing, such as the one conducted for Vermont (4), tend to oversimplify many of the underlying factors affecting the highway financing process, and as a result, the forecasting capabilities of such studies are limited.

The most comprehensive study performed in this field has been the 1976 National Highway Inventory and Performance Study (NHIPS) (5). The 1976 NHIPS was the first major study to apply the exacting methods of measuring highway performance that were first introduced in the 1974 National Highway Needs Report (6). The application of such highway performance measurements enabled the detailed projections of highway service, physical conditions, and operating conditions to be made under various highway revenue scenarios. Such projections represented a major departure from previous studies in that the relative effectiveness of various financing policies, in terms of highway performance, could now be readily assessed. However, the 1976 NHIPS and most other studies in this area did not explicitly consider many or all of the interactive economic factors that affect future highway financing and performance forecasts.

In the present study a computer model was developed as a tool to analyze the state highway financing problem, and the broad objectives of this study are mentioned below:

1. Incorporate appropriately the interaction between the economic factors and the highway financing and performance variables.
2. Develop a consistent and detailed technique to measure and project highway performance.
3. Provide sufficient flexibility such that the analysis procedure can account for a variety of state and national legislative options.
4. Minimize the modifications necessary to adapt and transfer the use of the model to geographical areas other than the state of Indiana.

The resulting computer model provides detailed projections of a variety of factors relating to highway financing and highway performance in Indiana. Such information enables the analyst to evaluate many of the dynamic processes simulated by the computer model. An overview of the entire modeling procedure used in the present study is presented in Figure 3.

The national macroeconomic forecasts are provided as input to the modeling procedure. These forecasts directly affect fuel efficiency projections, fuel consumption projections, state highway user revenues, projections of highway performance and projections of highway improvements. Fuel efficiency projections are made on the national level and are a critical component in the determination of

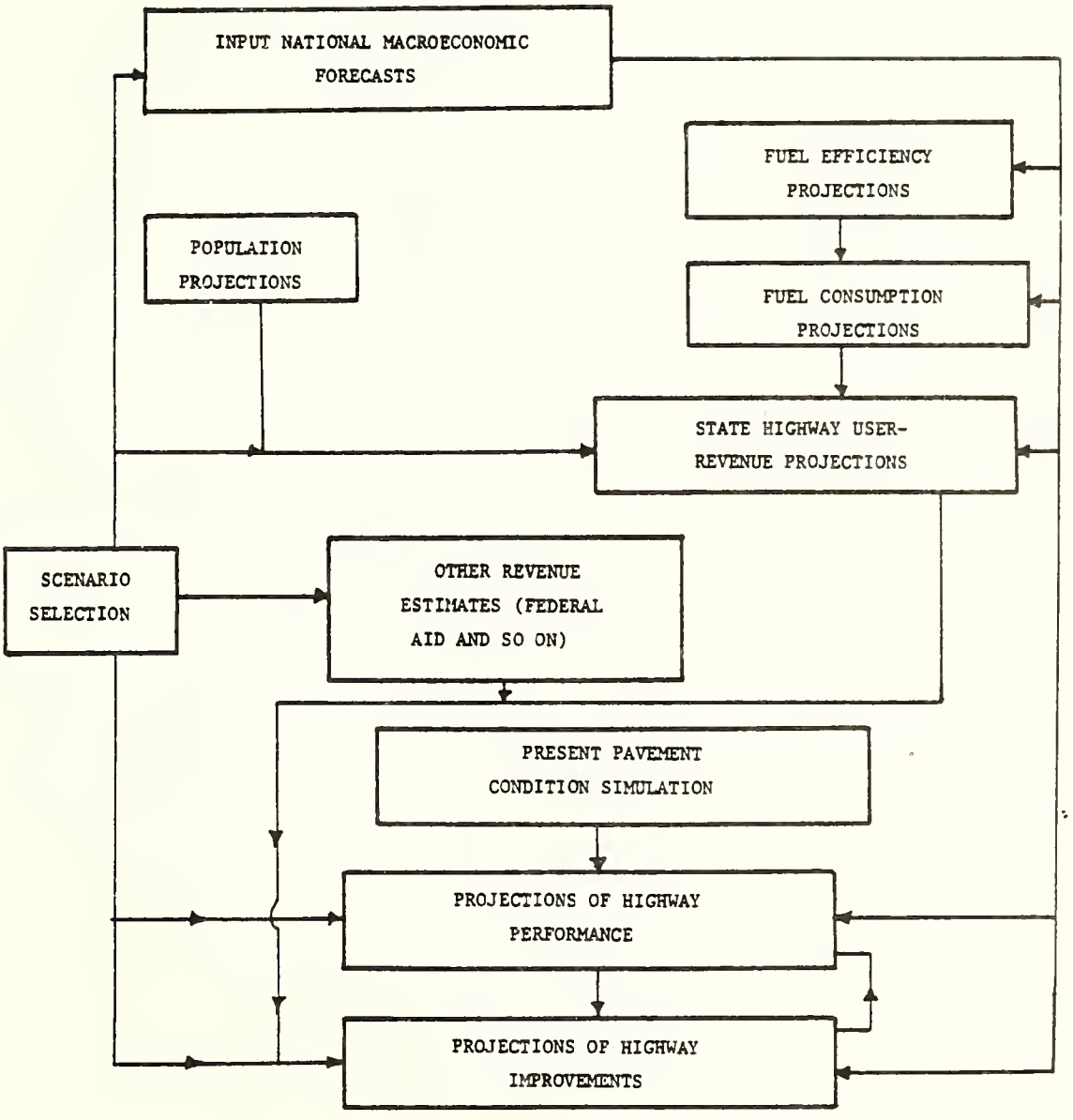

FIGURE 3. OVERVIEW OF THE SIMULATION PROCEDURE

fuel consumption projections which are in turn vital to the estimation of future state highway-user revenues. Additionally, Indiana population projections were made by the cohort survival method and are utilized to estimate the number of registered vehicles and the number of licensed drivers both of which are also important factors in the calculation of state highway-user revenues. Revenues from sources such as federal aid are estimated exogenously, and when combined with the internally projected state highway-user revenues constitute the total funds available for highway improvements. Finally, the present highway conditions are simulated internally and are used along with projections of highway improvements and other factors to estimate future highway performance which is the ultimate objective of the modeling procedure.

A more detailed explanation of the model simulation procedure is presented in the following chapters. The final two chapters are concerned with the application of the computer model to the Indiana highway financing problem.

CHAPTER 2

ECONOMIC AND ENERGY FORECASTS

In this chapter discussions are presented relating to the macroeconomic forecasts and energy assumptions incorporated in these forecasts. The macroeconomic forecasts including the associated energy assumptions were taken from the study conducted by Data Resources Inc. on a national level (7).

Macroeconomic Forecasts

The three national macroeconomic forecasts developed by Data Resources, Inc. (DRI), TRENDLONG 0978, CYCLELONG 0978, and PESSIMLONG 0978, were used in this analysis to provide a probable range of future economic conditions. These three forecasts are briefly outlined below:

TRENDLONG is essentially a stable long-run simulation of the U.S. economy. In this model the economy achieves a uniform Gross National Product (GNP) growth by the mid-1980's and full-employment is nearly reached after 1986. In addition, the federal budget and the national trade account achieve a near balance by the early 1980's.

CYCLELONG is a cyclical economic simulation model that forecasts the business cycles that have historically characterized the U.S. economy. The cyclical behavior is induced by factors such as financial pressures, inventory variations, foreign demand shifts, and

imperfect policy decisions. The loss of potential output results in a 1990 GNP that is 2.2% less than that projected by the TRENDLONG model.

PESSIMLONG is an economic simulation model that projects essentially the same price, exogenous factors, and final demand behavior that has typified the U.S. economy in the past 10 years. Inflation becomes increasinly troublesome and is fueled by inappropriate policy decisions and increasing food and oil prices. The resultant 1990 GNP is less than that projected by either of the other two models.

A summary of the basic assumptions underlying these macroeconomic forecasts is presented in Table 1. In Figure 4 are illustrated the GNP forecasts generated by these models. The assumptions involving energy supply and demand, as used in the preparing of the three macroeconomic forecasts, are discussed in detail in the next section.

Energy Supply and Demand

In recent years, a number of studies have been undertaken to forecast future energy demands and supplies. The results of such studies have varied considerably as there is much uncertainty relating to future energy reserves, the effectiveness of conservation efforts, and the impacts of technology. However, the general consensus of these studies indicates that the world faces long-term oil and gas shortages which will result from the inability of reserve additions to match energy consumption growth (8,9).

TABLE 1. MAJOR ASSUMPTIONS UNERLYING DRI MACROECONOMIC FORECASTS.

ASSUMPTIONS	TRENDLONG	CYCLELONG	PESSIMLONG
FISCAL POLICY	FEDERAL EXPENDITURES INCREASE AT A COMPOUND ANNUAL RATE OF 8.8 PERCENT WITH FEDERAL BUDGET BALANCE AFTER 1986.	FEDERAL EXPENDITURE INCREASE AT A COMPOUND ANNUAL RATE OF 9.3 PERCENT.	FEDERAL EXPENDITURES INCREASE AT A COMPOUND ANNUAL RATE OF 10.6 PERCENT.
MONETARY POLICY	TIGHTENING OF MONEY SUPPLY IN 1980 AS INFLATION ACCELERATES AND AFTERWORDS STABLE CREDIT IS PROMOTED.	FLUCTUATIONS IN POLICY CONTRIBUTE TO THE SEVERITY OF CYCLES.	
CONSUMER BEHAVIOR	LOW INFLATION AND JOB SECURITY INCREASE CONSUMER CONFIDENCE.	CYCLICAL VARIATIONS IN SENTIMENT RESULT IN LARGE FLUCTUATIONS IN DURABLE GOOD EXPENDITURES.	
BUSINESS BEHAVIOR	DECISIONS MADE IN A STABLE ENVIRONMENT.	OUTPUT FLUCTUATIONS AND INFLATION RESULT IN UNCERTAINTY AND INVESTOR CAUTION.	
INFLATION	CAPACITY UTILIZATION AND ENERGY INFLUENCE THE IMMEDIATE FUTURE WITH STEADY IMPROVEMENT BEGINNING IN THE EARLY 1980'S.	CONTINUAL BOOM-BUST PATTERN RAISES THE AVERAGE RATE.	AGGRESSIVE WAGE AND PRICE BEHAVIOR PUSHES RATES UPWARD AND INCREASES THE THE SEVERITY OF ECONOMIC SLOW DOWNS.

SOURCE: RFERENCE 7.

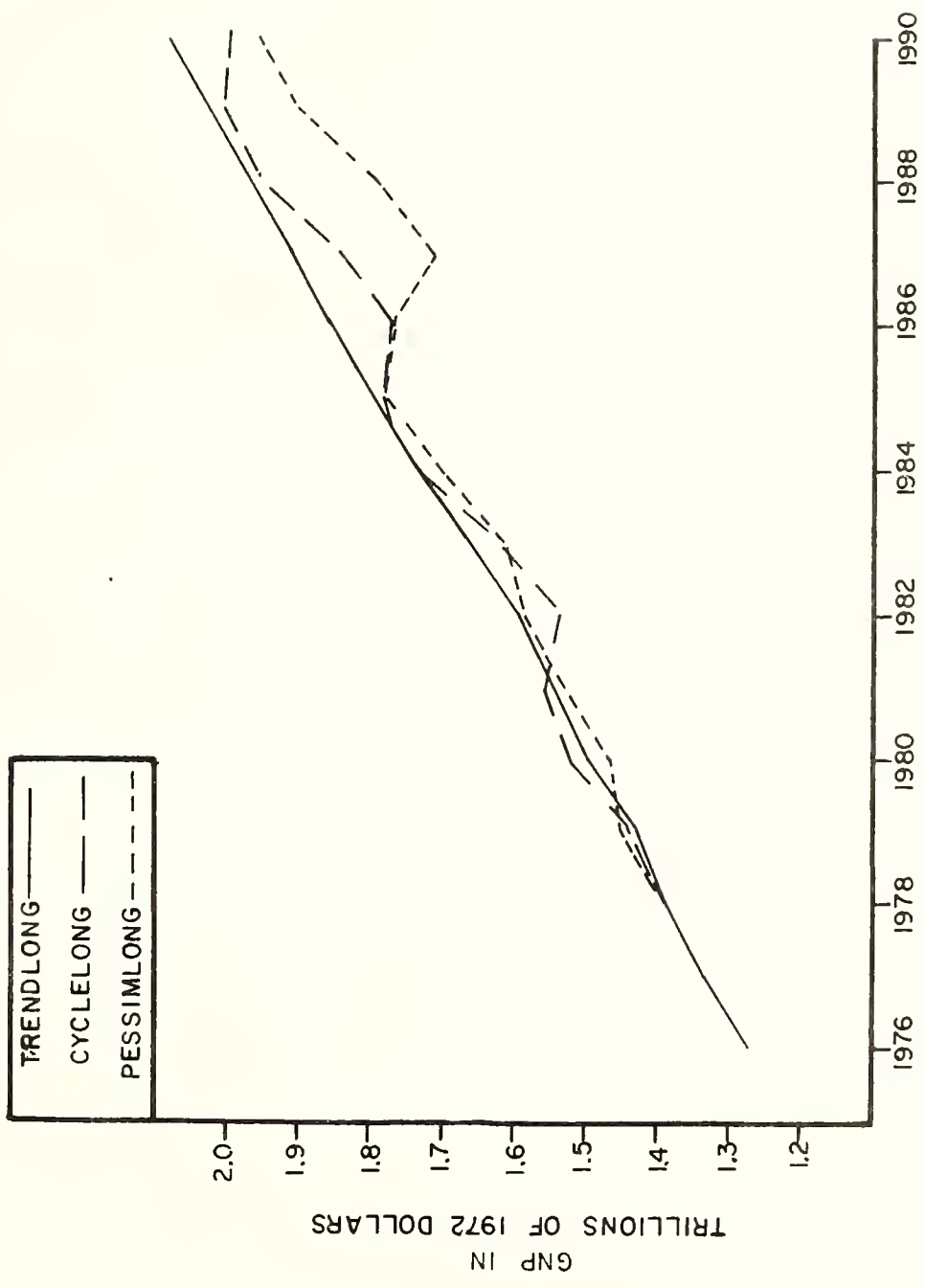

FIGURE 4. SUMMARY OF DRI GROSS NATIONAL PRODUCT (GNP) FORECASTS

SOURCE: REFERENCE 7.

As a result of these projected shortages, the growth in world energy demand must be curtailed such that future supply and demand equilibrium can be attained. The extent of this curtailment can be estimated by analyzing the four major factors influencing future world energy consumption; 1) economic growth, 2) energy prices, 3) inter-fuel substitution, and 4) availability of energy supplies. It must be noted that the above factors are interdependent and the following discussion is made considering this interdependency.

Economic Growth

In the past, a virtually unlimited supply of energy was available for economic growth. With the prospect of future energy shortages, it is necessary to set realistic economic growth goals and to achieve these goals with a more efficient use of limited energy supplies.

At the conclusion of the recent Bonn Summit meeting (July, 1978), seven heads of state released important statements regarding future energy actions. The emphasis of these actions was placed on conservation and increased domestic energy production. To achieve these objectives, aggressive conservation programs as well as the rapid development of domestic energy resources are necessary.

Table 2 summarizes the projected economic and energy growth rates resulting from the summit. These rates were utilized as input to the three macroeconomic models previously described. Barring any major disruptions in the world economic system, the goals set at the summit are quite reasonable and are likely to be achieved.

TABLE 2. ENERGY AND GNP RELATIONS, THE SEVEN SUMMIT COUNTRIES.

	COMPOUND ANNUAL GROWTH RATES (PERCENT)					
	1960-73		1973-77		1977-85	
	REAL GNP	ENERGY	REAL GNP	ENERGY	REAL GNP	ENERGY
EUROPE	4.9	5.0	1.6	0.4	3.3	2.6
JAPAN	10.3	11.2	3.1	0.1	5.1	3.6
CANADA	5.6	5.7	3.3	2.3	4.4	4.0
U.S.	4.1	4.1	2.0	0.3	3.8	2.8

	IMPLIED ENERGY-GNP ELASTICITY		
	1960-73	1973-77	1977-85
EUROPE	1.02	0.25	0.80
JAPAN	1.09	0.04	0.70
CANADA	1.02	0.68	0.90
U.S.	1.00	0.20	0.75

SOURCE: REFERENCE 7.

Energy Prices

Energy prices have been and will continue to be dominated by the price of crude oil. To a large extent, future world crude oil prices will be set by the OPEC cartel which controls an enormous percentage of the total non-communist oil and gas reserves. Most major energy studies have projected OPEC crude oil prices to remain constant in real terms (i.e. price increases equalling the rate of inflation) or increasing only slightly (8,9,10,11,12).

The average annual projected increases in OPEC crude oil prices utilized in the DRI macroeconomic models vary from 7.4% (1.5% above the average U.S. inflation rate) for the TRENDLONG model to 10.7% (2.8% above the average inflation rate) for the PESSIMLONG model. The actual domestic energy prices are influenced additionally by U.S. governmental policies. Current domestic oil prices are well below world levels and recent energy legislation, which proposes to raise domestic oil prices to world levels by 1980, is given virtually no chance of passing. However, increases in nonregulated domestic oil production from the Alaskan slope, enhanced recovery techniques, and stripper wells, will raise the average price of domestic oil over the next few years. As a result, wholesale fuel prices will rise at a more rapid rate than import fuel prices.

The DRI fuel pricing projections are summarized in Table 3.

Interfuel Substitution

The ability of world economies to convert primary oil and gas consumers to consumers of more plentiful energy sources (such as coal

TABLE 3. SUMMARY OF DRI ENERGY-RELATED PROJECTIONS (COMPOUND ANNUAL GROWTH RATES IN PERCENT).

	TRENDLONG 1977-90	CYCLELONG 1977-90	PESSIMLONG 1977-90
FUEL IMPORTS			
PRICE OF FUEL IMPORTS	7.4	9.2	10.7
REAL FUEL IMPORTS	2.4	2.4	2.4
DOMESTIC PRICES			
WHOLESALE FUEL PRICE	8.9	10.4	11.0
GASOLINE PRICE DEFLATOR	6.2	7.3	8.2
GNP PRICE DEFLATOR	6.1	6.8	7.9

SOURCE: REFERENCE 7.

and nuclear energy) will be an important factor in determining future energy supply and demand equilibrium. The extent of non-OPEC coal resources is substantial. However, due to the inherent time lag in coal conversions resulting from technological problems and short-term coal production limitations, the importance of coal in the total energy picture will be one of only gradual increase over the time period of this analysis.

It is generally acknowledged that the environmental problems associated with nuclear energy will affect only its short-term growth rates and the continual search for inexpensive energy sources will make nuclear energy an increasingly important energy source throughout the 1980's. Other energy sources, such as solar and geothermal, cannot be expected to make significant contributions to the world energy needs until at least the 1990's.

In conclusion, although interfuel substitution will become a relatively important factor in reducing oil and gas demand pressures (particularly in the late 1980's), it must be realized that oil and gas will remain the dominant energy sources well into the 1990's.

A perspective of U.S. energy supply by type of energy source is presented in Figure 5.

Energy Supplies

Future world energy supplies will be determined by; 1) the energy production of energy importing nations, 2) the OPEC energy production, 3) the energy production of communist nations.

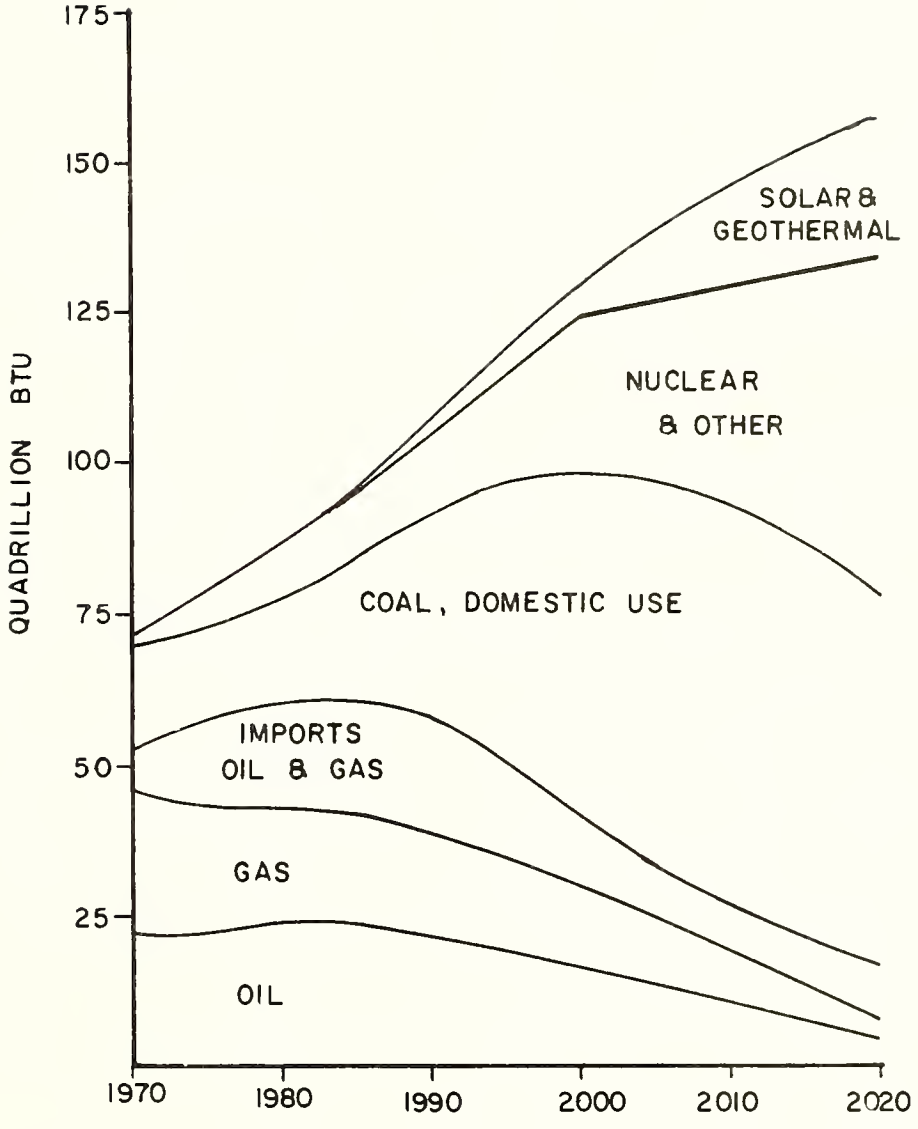

FIGURE 5. A PERSPECTIVE OF U.S. LONG-TERM ENERGY SUPPLY

SOURCE: REFERENCE 12.

Estimates of energy production among energy importing nations, represented here by the Organization for Economic Cooperation and Development (OECD) which includes most major non-communist industrial nations, are provided by the Department of Energy (12) and are summarized in Figure 6. This figure is based on the Department of Energy (DOE) projection series C which used an earlier run of the DRI TRENDLONG model to project future world economic conditions and whose basic energy and economic assumptions are similar to those used in the TRENDLONG model run utilized in this analysis. Table 4 reveals that despite significant increases in OECD energy production, the OECD nations will become even more dependent on non-OECD energy imports in the future.

The projected U.S. petroleum and natural gas supplies, under the same DOE projection scenario C (Figures 7 and 8), reflect the future U.S. dependence on imported energy.

As a result of the energy import needs of OECD nations, the OPEC energy production (specifically oil) is the critical driving force in all energy related projections. Estimations of OPEC oil production capabilities vary considerably. But it is generally realized that sufficient OPEC production capacity exists to meet world needs until at least the 1990's providing that controlled worldwide energy growth rates are achieved.

Much uncertainty shrouds the role that communist nations will play in the world energy balance. It seems most likely that the role of communist nations as net importers or net exporters of energy will be relatively small for some time.

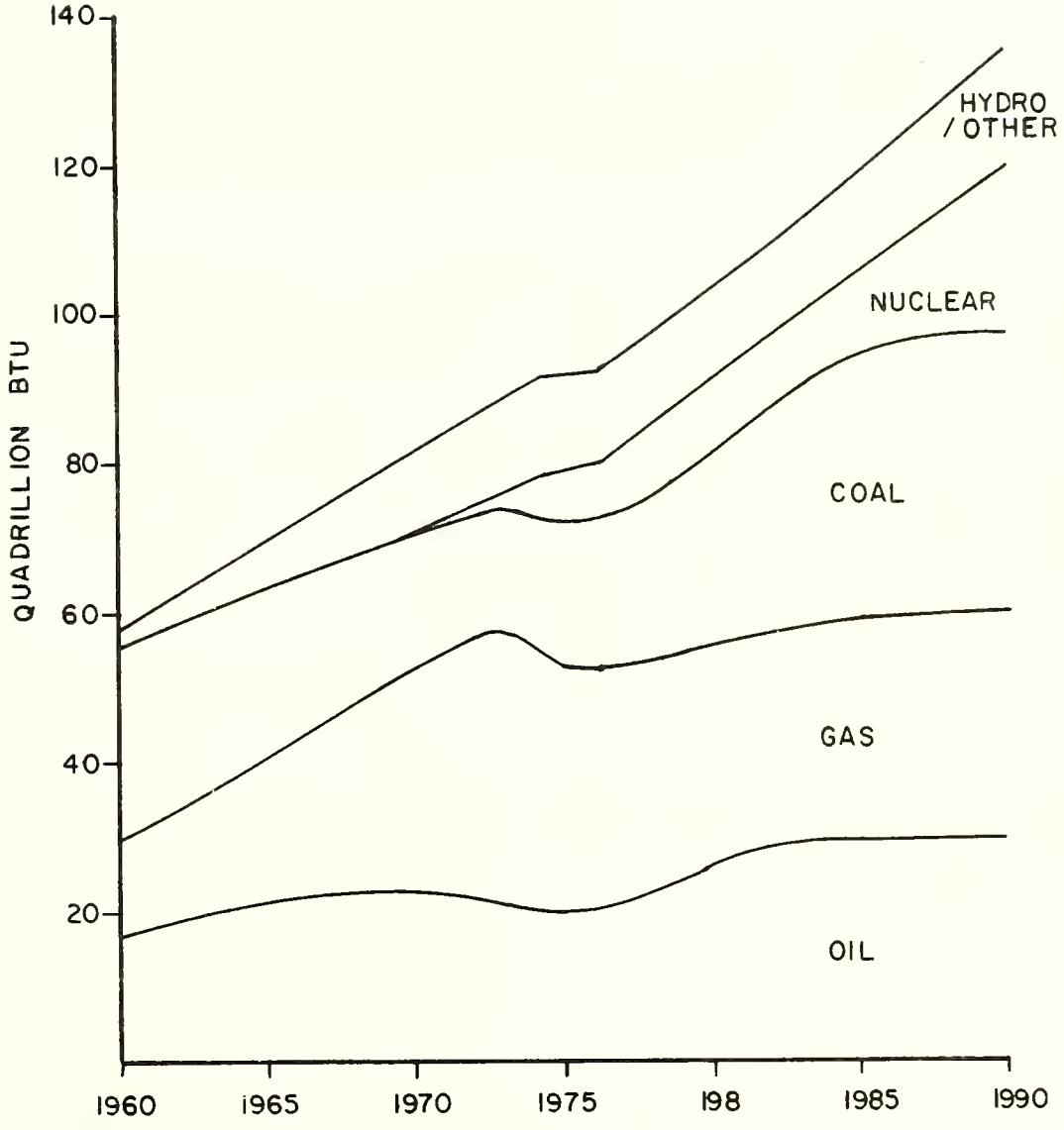

FIGURE 6. OECD ENERGY PRODUCTION 1960—1990 DEPARTMENT OF ENERGY, PROJECTION SERIES C

SOURCE: REFERENCE 12.

TABLE 4. OECD DEPENDENCE UPON ENERGY IMPORTS FROM NON-OECD COUNTRIES (PERCENT OF ENERGY CONSUMPTION). DOE PROJECTION SERIES C.

	1975 ACTUAL	1985	1990
UNITED STATES	16	24	27
CANADA	24	13	22
OECD EUROPE	60	52	55
AUSTRALIA/ NEW ZEALAND	27	24	29
JAPAN	85	79	79
TOTAL OECD	37	39	43

SOURCE: REFERENCE 12.

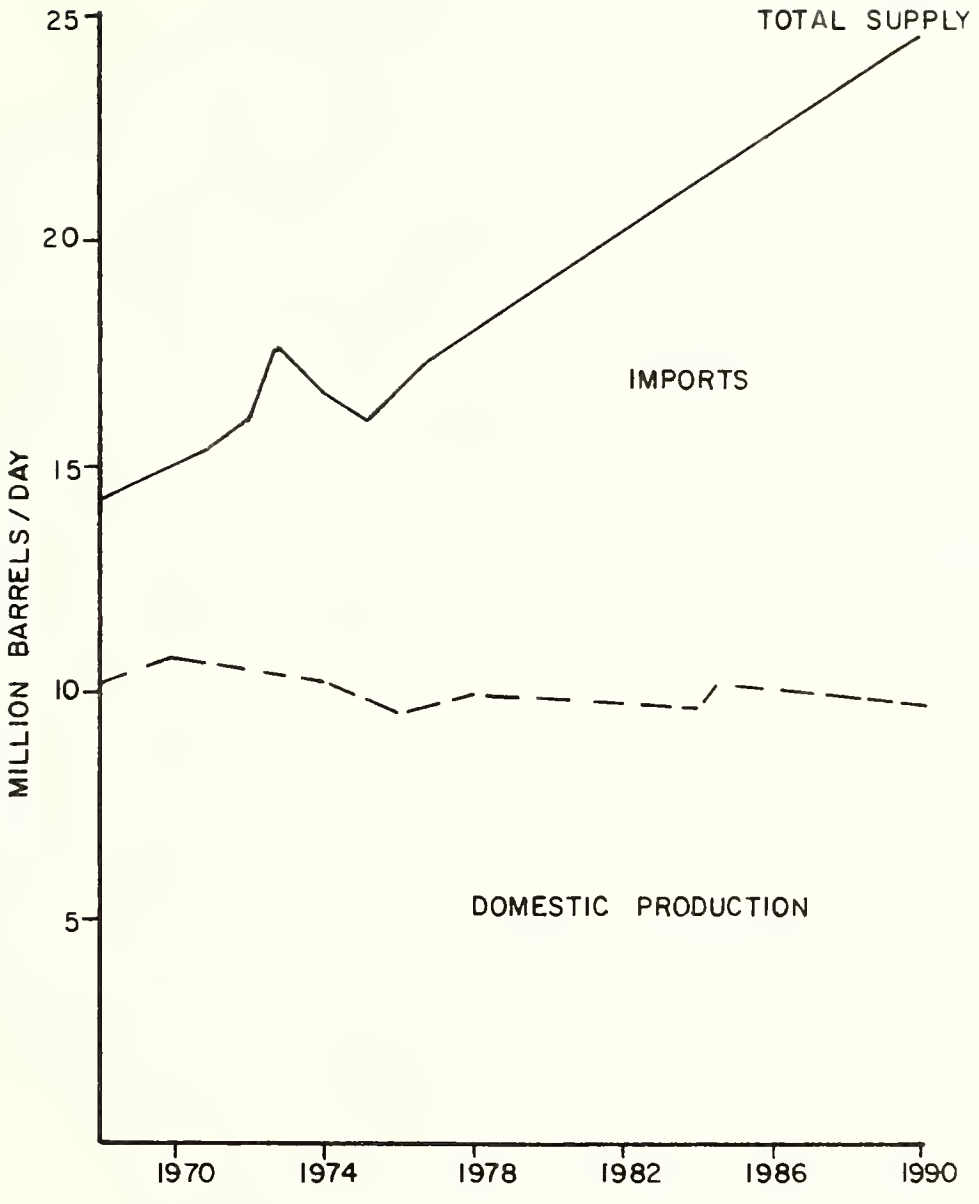

FIGURE 7. PROJECTED U.S. PETROLEUM LIQUIDS SUPPLY
DEPARTMENT OF ENERGY PROJECTION SERIES C

SOURCE: REFERENCE 12.

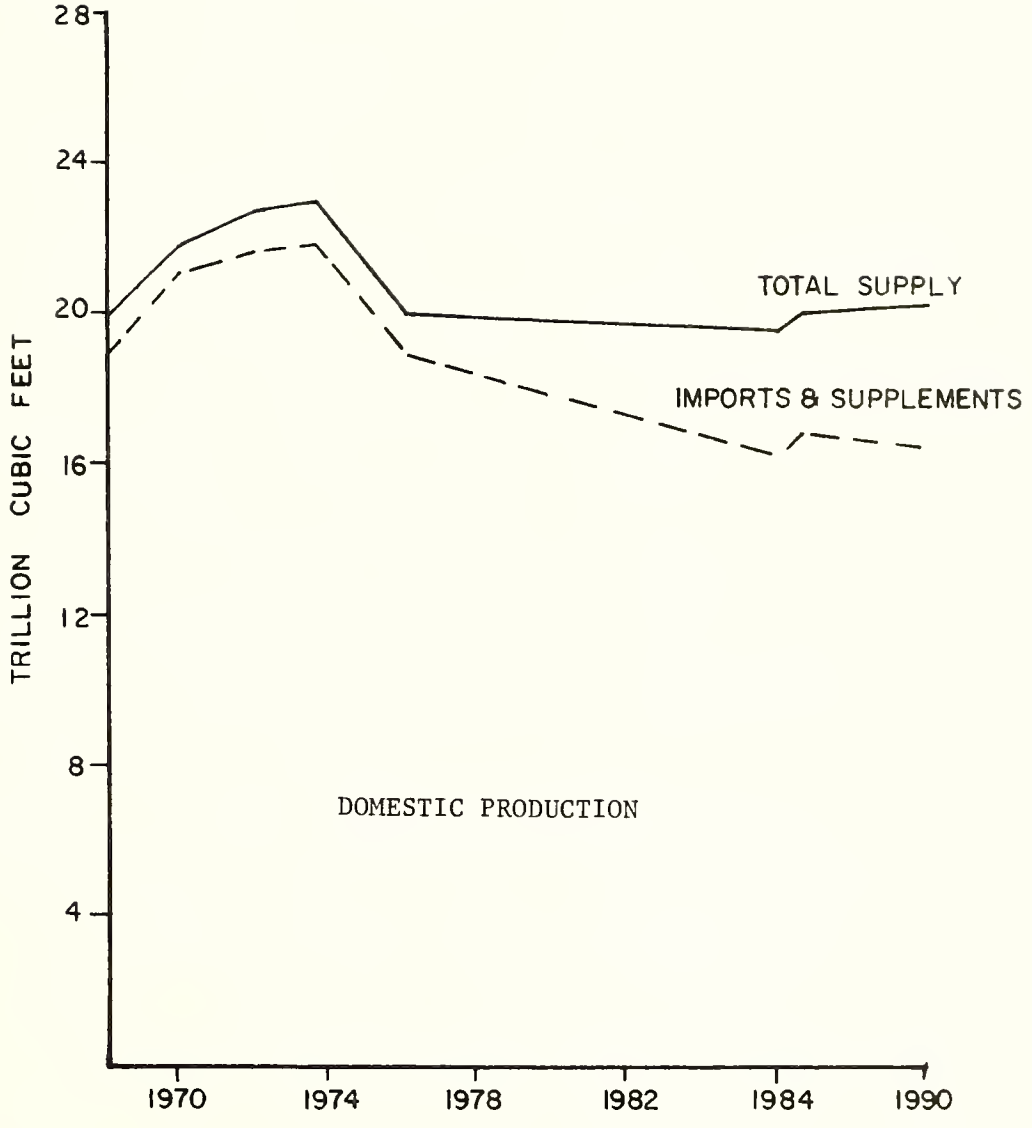

FIGURE 8. PROJECTED U.S. NATURAL GAS SUPPLY
DEPARTMENT OF ENERGY PROJECTION SERIES C

SOURCE: REFERENCE 12.

Table 5 presents a comparison of major study forecasts regarding world oil production and consumption in 1985.

TABLE 5. COMPARISON OF ALTERNATIVE WORLD OIL FORECASTS FOR 1985 (MILLION BARRELS PER DAY).

	DOE 1/	CIA 2/	CRS 3/	WAES 4/	OECD 5/
WORLD OIL CONSUMPTION 6/	66	70	69	61	64
NON-OPEC PRODUCTION 6/	24	25	25	23	25
NET COMMUNIST EXPORTS	-2.5	-4	1	NA	1
OPEC PRODUCTION	44.5	49	43	38	39

1/ DEPARTMENT OF ENERGY, PROJECTIONS OF ENERGY SUPPLY AND DEMAND AND THEIR IMPACTS, PROJECTION SERIES C, APRIL 1978.
2/ THE INTERNATIONAL ENERGY SITUATION: OUTLOOK TO 1985, APRIL 1977,MEDIAN FORECAST.
3/ CONGRESSIONAL RESEARCH SERVICE, PROJECT INTERDEPENDENCE, JUNE 1977.
4/ WORKSHOP ON ALTERNATIVE ENERGY STRATEGIES PROJECT, GLOBAL PROSPECTS 1985-2000, MAY 1977, AVERAGE OF CASES PRESENTED.
5/ OECD WORLD ENERGY OUTLOOK, APRIL 1977, REFERENCE CASE.
6/ EXCLUDES CENTRALLY PLANNED ECONOMIES.

SOURCE: REFERENCE 12.

CHAPTER 3

FUEL EFFICIENCY PROJECTIONS

In this study, fuel efficiencies are projected for five vehicle types: a) auto, b) motorcycle, c) bus, d) single-unit truck, and e) combination truck. Projections of auto fuel efficiencies were achieved through a modeling procedure, whereas all other vehicle categories were projected using simple linear extrapolation. Details of the assumptions and techniques used for such projections are presented in the following sections.

Auto Fuel Efficiency Model

The estimation of future auto fleet fuel efficiencies is of vital importance to the projection of revenues derived from fuel taxes. Previous efforts in this area have been highly simplified or have ignored the causal economic factors which affect future fleet fuel efficiencies (2,3,13). The approach developed for the present study considered the possible effects of the national economic climate and included a high degree of interaction between the prevailing economic conditions and the model parameters.

The basic approach used in the model is to a) determine the number of autos in use by model year, b) estimate auto fuel efficiencies by model year, and c) establish the relative auto usage by model year. Once these items are estimated, the average auto fleet

fuel efficiency can be readily determined. The entire model simulation procedure is outlined in Figure 9.

As the state level data was not available for Indiana, the auto fleet fuel efficiency values were generated on the national level and then applied to the Indiana auto fleet.

A detailed discussion of the auto model components is presented in the following paragraphs.

Determination of the Number of Autos in Use by Model Year

The base year information is provided as input data. A cohort survival technique is then utilized to predict the number of autos in use by model year for the subsequent simulation years. The three major components of this technique are described below.

New Car Sales - The obvious impact of new car sales is that it will directly determine the population of the first cohort. However, in addition, new car sales will affect the survival rates of older model years since it is inherently assumed that the same economic conditions that influence new car purchases also influece auto scrappage decisions. Historical data supports this assumption (14).

Alternate projections of new car sales provided by the three macroeconomic model runs prepared by DRI were used for the purpose of this study. These projections are presented in Figure 10. As might be expected, new car sales are influenced considerably by economic conditions as indicated by the variation is sales between the three DRI models.

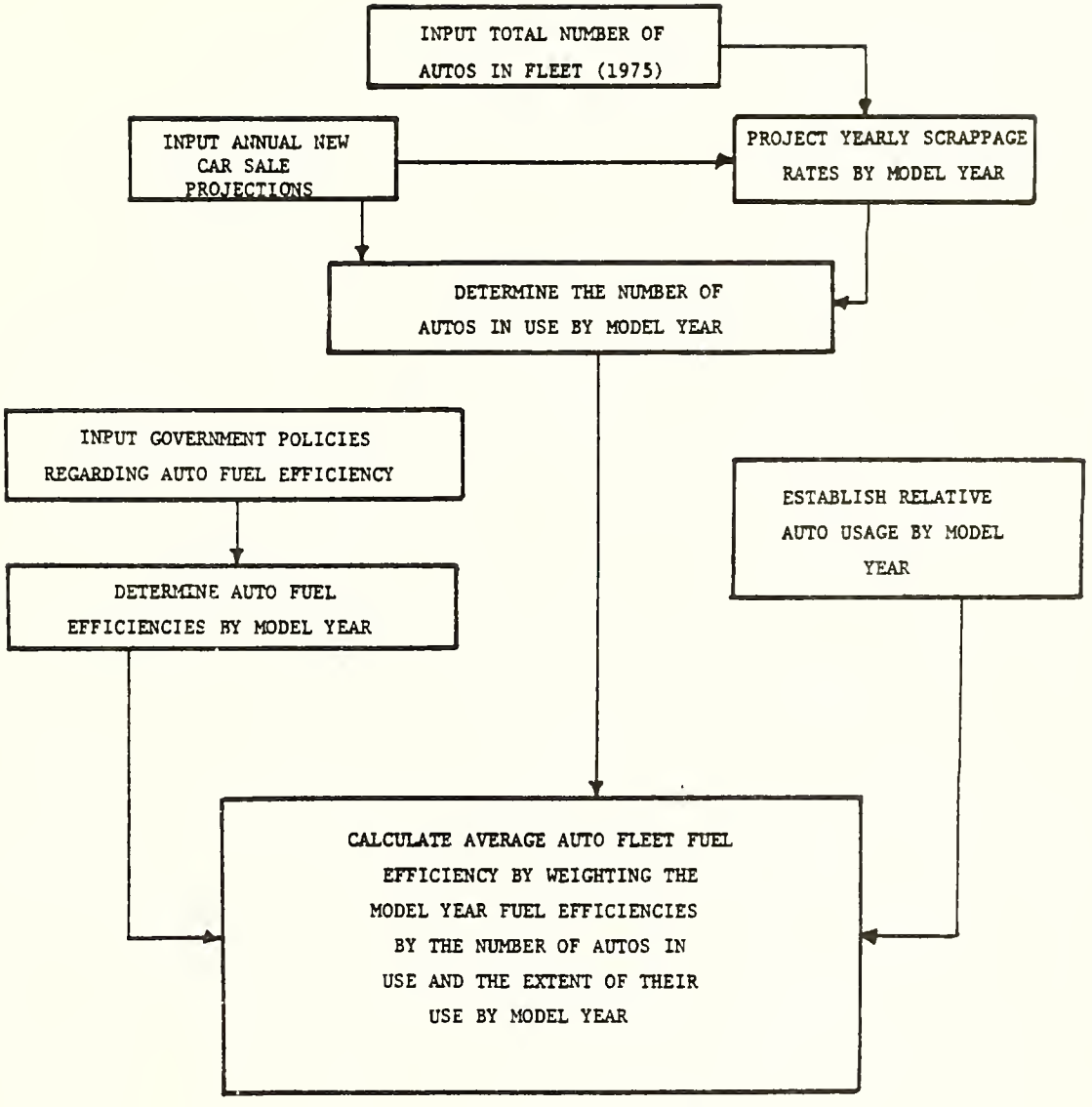
INPUT TOTAL NUMBER OF AUTOS IN FLEET (1975)
INPUT ANNUAL NEW CAR SALE PROJECTIONS
PROJECT YEARLY SCRAPPAGE RATES BY MODEL YEAR
DETERMINE THE NUMBER OF AUTOS IN USE BY MODEL YEAR
INPUT GOVERNMENT POLICIES REGARDING AUTO FUEL EFFICIENCY
ESTABLISH RELATIVE AUTO USAGE BY MODEL YEAR
DETERMINE AUTO FUEL EFFICIENCIES BY MODEL YEAR
CALCULATE AVERAGE AUTO FLEET FUEL EFFICIENCY BY WEIGHTING THE MODEL YEAR FUEL EFFICIENCIES BY THE NUMBER OF AUTOS IN USE AND THE EXTENT OF THEIR USE BY MODEL YEAR

FIGURE 9. SIMULATION PROCEDURE FOR AUTO FUEL EFFICIENCY MODEL

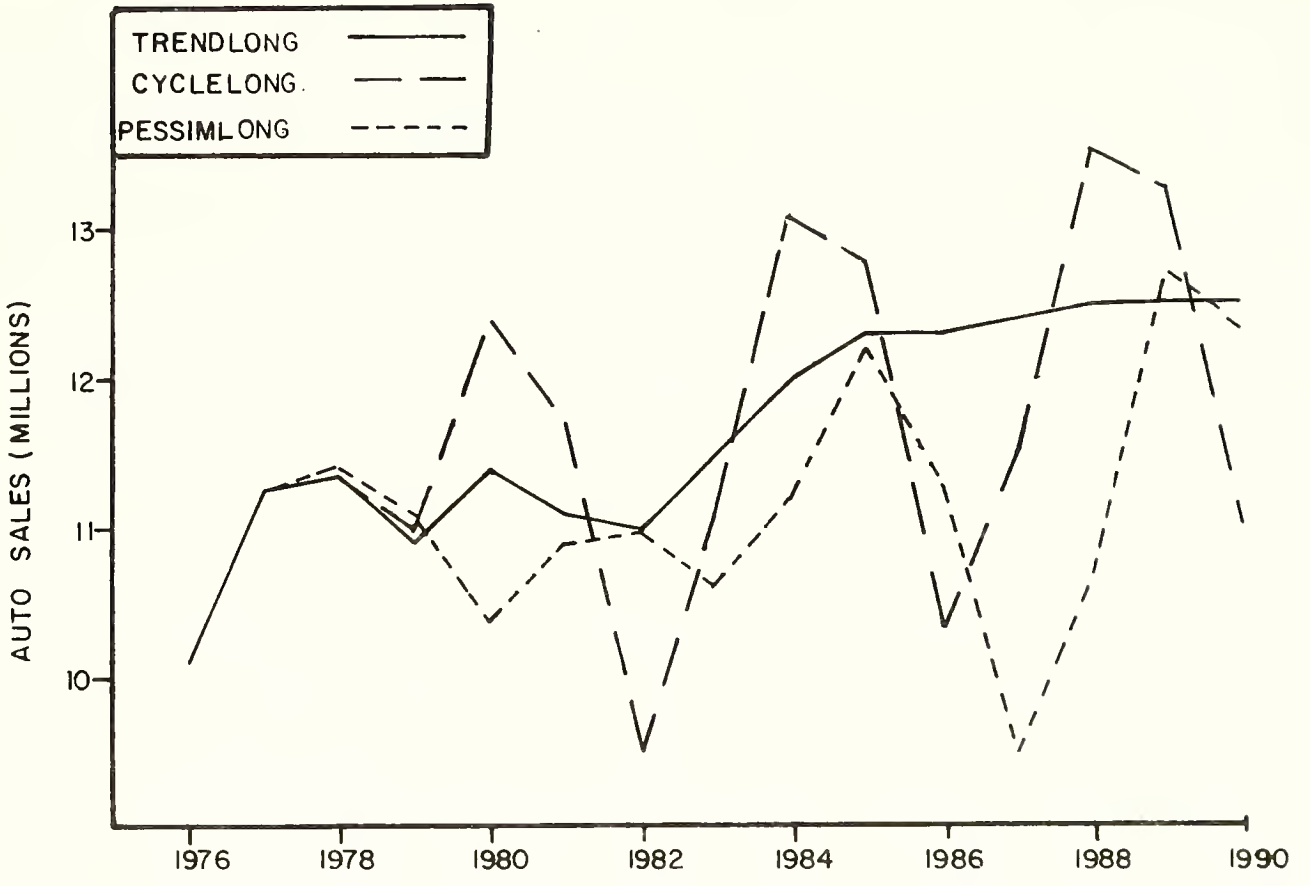

FIGURE 10. SUMMARY OF DRI NEW CAR SALES FORECASTS

SOURCE: REFERENCE 7.

Automobile Ownership - Clearly, total auto ownership will have a direct impact on survival rates and therefore its accurate projection is vital to model accuracy. For the purpose of this study, the national auto ownership forecasts developed by DRI, based on three scenarios of national economic conditions, were used. These projections are presented in Table 6.

Survival Rates - A survival rate is defined as the probability of a vehicle of a particular model year surviving to the next calendar year, and the appropriate base year values were developed on the basis of the data given in the reports provided by R. L. Polk and Company (14), in which the number of autos in use by model year are estimated.

A number of approaches have been used by previous researchers to estimate future auto survival rates. One of the most notable research efforts (15) in this area applied a Weibull distribution to approximate existing survival rates. Although this approach provided reasonably good estimates of existing survival rate distributions, the projection of future survival rates proved to be inaccurate due to the inherent instability of the survival rate distribution over time. To overcome this problem a procedure was developed in the present study that indirectly approximates future survival rate distributions by estimating annual changes in each cohort survival rate.

The primary task of the proposed procedure is to estimate the relative magnitude of change in each cohort survival rate. An analysis of past data revealed that during periods of high overall

TABLE 6. SUMMARY OF DRI NATIONAL AUTOMOBILE OWNERSHIP FORECASTS (IN MILLIONS).

YEAR	TRENDLONG	CYCLELONG	PESSIMLONG
1976	98.7	98.7	98.7
1977	100.8	100.8	100.8
1978	103.0	103.0	103.0
1979	105.6	105.7	105.9
1980	108.5	109.4	108.4
1981	111.0	111.9	110.7
1982	113.0	112.9	112.7
1983	115.4	115.1	114.8
1984	118.2	118.7	116.9
1985	120.9	122.0	119.5
1986	123.5	123.5	122.4
1987	126.0	126.0	124.6
1988	128.3	129.6	126.9
1989	130.5	132.9	129.8
1990	132.3	134.8	132.4

SOURCE: REFERENCE 7.

survival rate change the survival rates of the older cohorts varied more than those of newer cohorts. This phenomenon is illustrated in Figure 11 and can be attributed to the fact that a larger number of older autos are marginally economic. Therefore, a shift in economic conditions will logically have a larger impact on older auto scrappage decisions and, subsequently, on survival rates.

The above observation led to the development of a random assignment procedure to approximate survival rates. This procedure is based on the assumption that there exists a number of "select" marginally economic autos which can be envisioned as those marginally economic autos that are most likely to be affected by changes in national economic conditions. The number of these autos is computed as the difference between the actual auto ownership and the auto ownership estimated by calculating surviving autos, using the survival rates from the preceding year and adding new car sales. This assumption is based on historical data (14) which reveals a definite relationship between prevailing economic conditions and the magnitude of the difference referred to above. The magnitude of this difference in turn reflects the amount of change in the survival rates, of each cohort, from year to year.

Subsequently, data from years with high survival rate changes was used to determine the historical probabilities of "select" marginally economic autos being retired or retained in each cohort. These historical probabilities were calculated from the following equation:

$$CP = \frac{ACSA - (SURV_{-1} * CPOP_{-1})}{\sum_{i=1}^{n} CPOP - \sum_{i=1}^{n} (SURV_{-1} * CPOP_{-1})} \qquad (3.1)$$

where

CP = the cohort probability of a "select" marginally economic auto being retired or retained in that cohort during a given year.

ACSA = actual number of surviving autos in the cohort.

$SURV_{-1}$ = preceding year's survival rate.

$CPOP_{-1}$ = cohort population of preceding year.

CPOP = present cohort population.

n = total number of cohorts.

The results of the application of the above equation were used to create the following regression equation. The t-values are indicated in parentheses.

$$Y = \underset{(4.93)}{.02684} + \underset{(15.69)}{.000127(X)^3} \qquad (3.2)$$

$$F = 246.26 \qquad R^2 = .965$$

where

Y = the probability of a "select" marginally economic auto being retired or retained in cohort of age X.

X = the age of the cohort in years.

In this analysis, the age of the cohorts (X in the above equation) ranged from 1 to 12 years with the 12th year cohort including all autos 12 years old and older. It was decided to include autos of 12 years or older in the final cohort since the survival

rates of autos at this age or older stabilize at approximately the same rate (see Figure 11).

The number of "select" marginally economic autos in any future year is determined from:

$$SMEA = AO - \left[\sum_{i=1}^{n} (SURV_{-1} * CPOP_{-1}) + NCS \right] \qquad (3.3)$$

where

SMEA = the number of "select" marginally economic autos in given year.

AO = projected auto ownership in given year (see Table 6).

$SURV_{-1}$ = cohort survival rate in preceding year.

$CPOP_{-1}$ = cohort population in preceding year.

NCS = new car sales in given year.

These autos (SMEA) are assigned (or detracted, if negative) from specific cohorts using a random number generator and the probabilities estimated in equation 3.2. Each cohort survival rate is then revised (for future use) such that the multiplication of the survival rate by the cohort population of the preceding year is equal to the new cohort population after the random assignment technique described above is implemented. This procedure is illustrated by the following equation:

$$RCSR = \frac{SURV_{-1} * CPOP_{-1} + AMA}{CPOP_{-1}} \qquad (3.4)$$

where

RCSR = the revised cohort survival rate.

$SURV_{-1}$ = the cohort survival rate of the previous year.

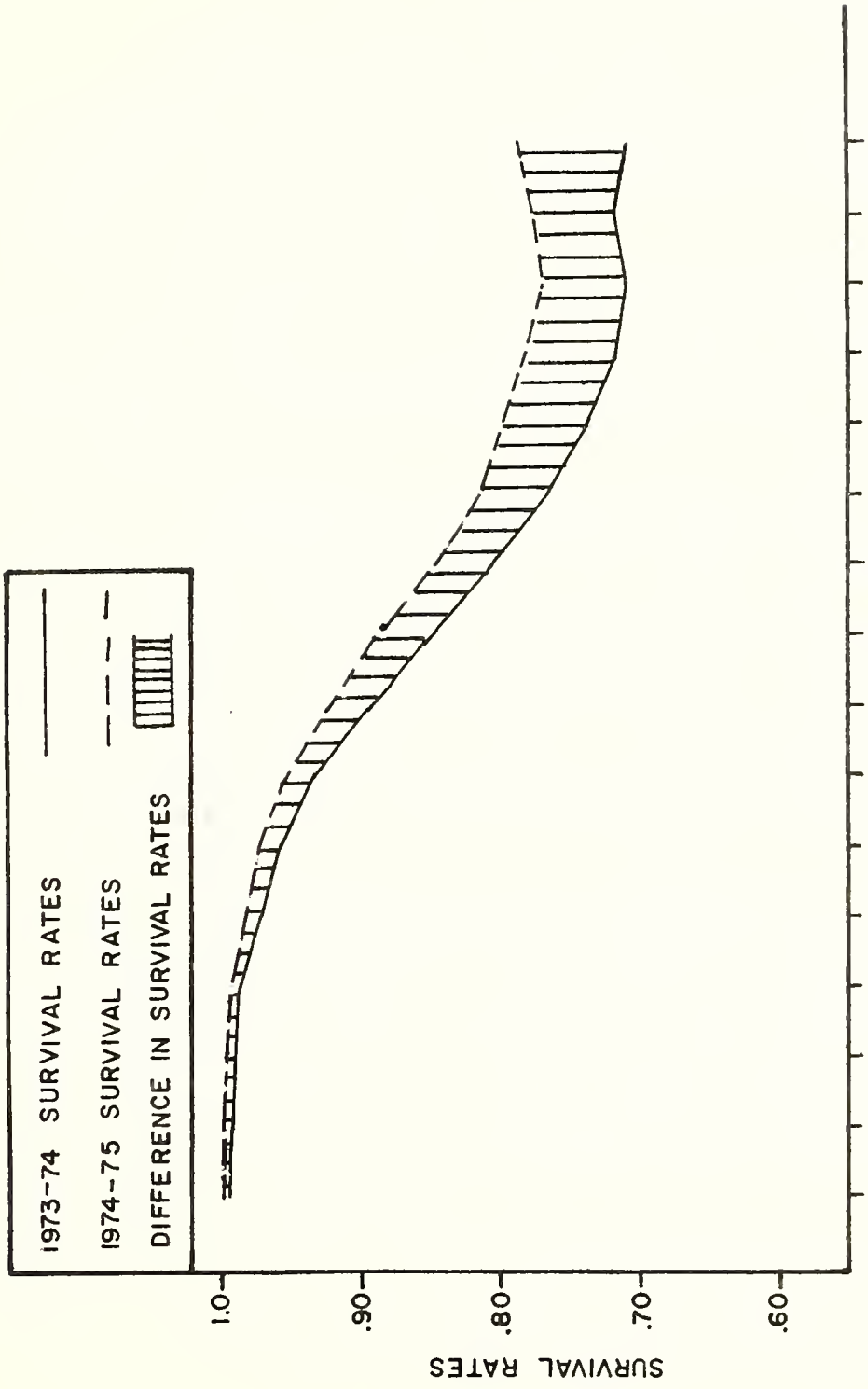

FIGURE 11. CHANGES IN SURVIVAL RATE DISTRIBUTIONS BETWEEN YEARS OF HIGH OVERALL SURVIVAL RATE CHANGES

$CPOP_{-1}$ = the cohort population in the preceding year.

AMA = total number of assigned or detracted autos in the cohort during the desired year.

Equations 3.3 and 3.4 are applied annually until the target year is reached. Thus, the number of autos existing in each cohort, during any given year, can be estimated.

This procedure was validated by estimating historical survival rate changes, and it was found that such estimations compared favorably with historical survival rate changes (14).

Future Auto Fuel Efficiencies by Model Year

Auto fuel efficiency information is provided as exogenous data to the model. The average model year fuel efficiencies can easily be established since the average efficiency of each existing model year is known from existing data and future fuel efficiencies can be assumed to conform with those mandated by government regulations (see Table 7).

Relative Auto Usage by Vehicle Age

Studies have shown that newer autos generally accumulate more annual miles than do older autos (17,18). The most recent study (The Nationwide Personal Transportation Survey 1969-70) was used to develop the following regression equation which estimates the relative auto usage by auto age.

$$Y = 1.8535 - .4813 \text{ LN } (X + 1) \qquad (3.5)$$
$$(20.38) \quad (-10.039)$$
$$F = 100.796 \qquad R^2 = .92$$

TABLE 7. MANDATED FEDERAL FUEL ECONOMY STANDARDS FOR AUTOS.

MODEL YEAR	MILES PER GALLON
1978	18.0
1979	19.0
1980	20.0
1981	21.5
1982	23.0
1983	24.5
1984	26.0
1985 AND BEYOND	27.5

SOURCE: REFERENCE 16.

where

Y = weighted usage by auto age.

X = age of auto in years (e.g. X=0 for autos 0-1 years,
X=1 for autos 1-2 years, etc.)

Auto Fleet Fuel Efficiency Calculations

Overall auto fleet fuel efficiency can now be determined simply by multiplying the average fuel efficiencies of each cohort by; a) the number of autos in use in each cohort divided by the total number of autos in use and b) the relative usage factors estimated from the above equation. The summation of these multiplications will be the average auto fleet fuel efficiency in any given year. The above calculation is represented by Equation 3.6.

$$AFE = \sum_{i=1}^{n} \left(\frac{CPOP}{TPOP} * RUF * CFE\right) \qquad (3.6)$$

where

AFE = auto fleet fuel efficiency in desired year.

CPOP = cohort auto population in desired year.

TPOP = total auto population in desired year.

RUF = relative usage factor calculated in Equation 3.5.

n = total number of cohorts.

CFE = average cohort fleet fuel efficiency.

Other Vehicle Fuel Efficiency Estimations

Due to data limitations, fuel efficiency values for other vehicle types cannot be estimated in a detailed manner. Therefore, the fuel efficiency projections of these vehicle types were made by extrapolating

recent efficiency estimates (1) and utilizing the results of previous studies (2,3). Table 8 summarizes the appropriate fuel efficiency projections.

The fleet fuel efficiencies determined in this chapter are used to estimate annual fuel consumption which is then used to project motor fuel tax revenues. The technique utilized to estimate annual fuel consumption is discussed in the next chapter.

TABLE 8. SUMMARY OF FUTURE FUEL CONSUMPTION ESITMATES.

YEAR	CYCLE MPG	BUS MPG	TRUCKS SINGLE UNITS MPG	TRUCKS COMBINATIONS MPG
1976	50.00	5.29	10.56	5.77
1977	50.00	5.33	10.37	5.86
1978	50.00	5.37	10.56	5.95
1979	50.00	5.41	10.75	6.04
1980	50.00	5.44	10.94	6.13
1981	50.00	5.47	11.14	6.22
1982	50.00	5.51	11.34	6.32
1983	50.00	5.54	11.55	6.42
1984	50.00	5.57	11.75	6.51
1985	50.00	5.61	11.96	6.61
1986	50.00	5.64	12.18	6.71
1987	50.00	5.67	12.40	6.81
1988	50.00	5.71	12.62	6.91
1989	50.00	5.74	12.85	7.01
1990	50.00	5.80	13.08	7.12

CHAPTER 4

FUEL CONSUMPTION ESTIMATES

An accurate fuel consumption estimate is vital to the prediction of future fuel tax revenues. The approach most commonly used to project fuel consumption is to annually estimate a) future vehicle-miles of travel and b) future fleet fuel efficiencies. Once the above two elements have been determined, total fuel consumption can be obtained simply by dividing vehicle-miles of travel by fleet fuel efficiencies (in miles per gallon).

An outline of the modeling approach used in this analysis is presented in Figure 12. A detailed discussion of the components of this model procedure is given in the following paragraphs.

Determination of Total Vehicle-Miles of Travel (VMT)

The use of a regression model to predict national VMT is the most widely used technique. The independent variables used in previous national VMT regression equations include (19):

1. Relative price of gas and oil
2. Change in consumer price index
3. Real disposable income
4. Cost per vehicle-mile traveled
5. Unemployment rate
6. Population

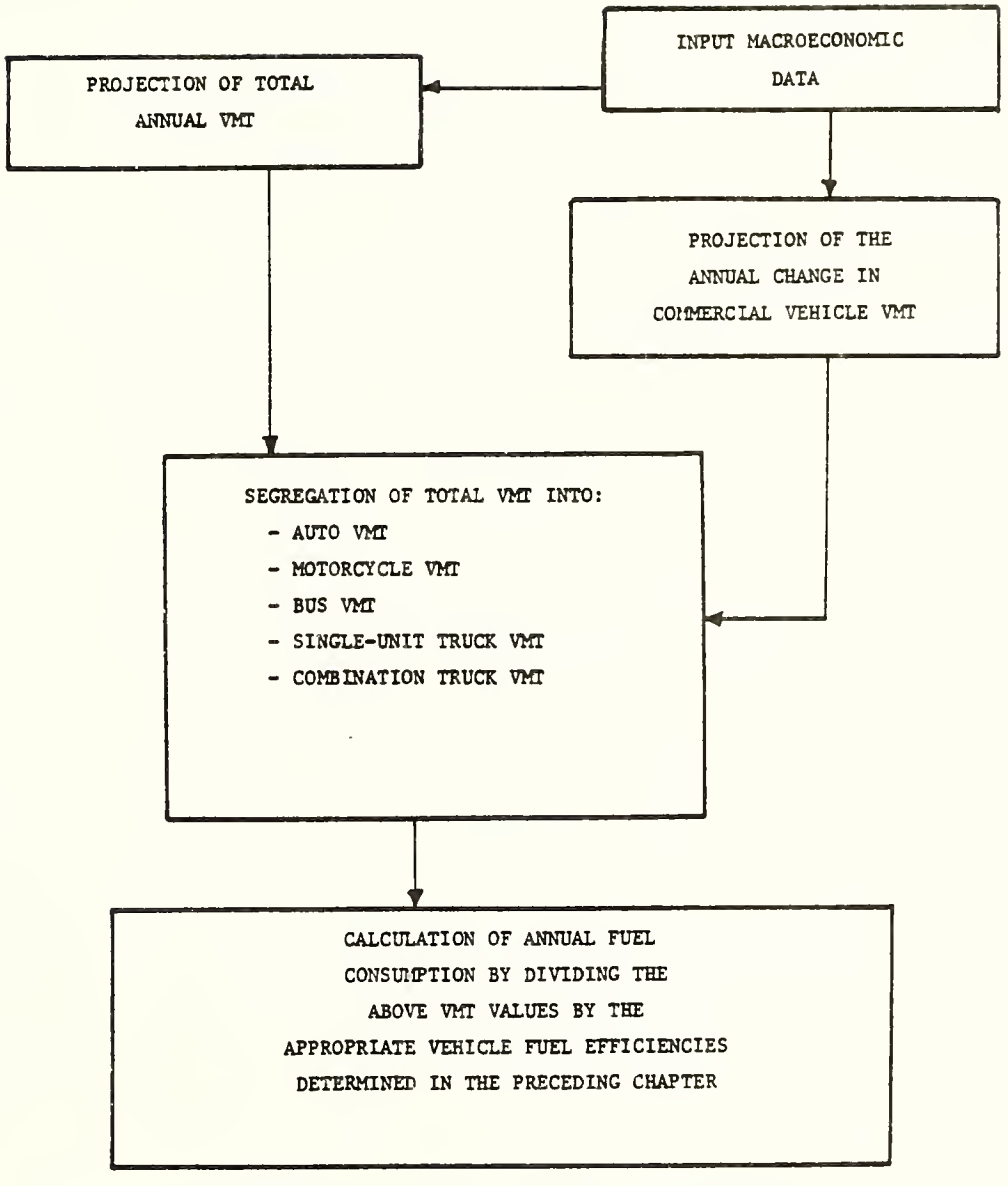
INPUT MACROECONOMIC DATA
PROJECTION OF TOTAL ANNUAL VMT
PROJECTION OF THE ANNUAL CHANGE IN COMMERCIAL VEHICLE VMT
SEGREGATION OF TOTAL VMT INTO:
- AUTO VMT
- MOTORCYCLE VMT
- BUS VMT
- SINGLE-UNIT TRUCK VMT
- COMBINATION TRUCK VMT
CALCULATION OF ANNUAL FUEL CONSUMPTION BY DIVIDING THE ABOVE VMT VALUES BY THE APPROPRIATE VEHICLE FUEL EFFICIENCIES DETERMINED IN THE PRECEDING CHAPTER

FIGURE 12. SIMULATION PROCEDURE FOR THE FUEL CONSUMPTION MODEL

7. Number of autos in use

8. Number of households

9. Transit supply

Several forms of regression models were attempted into various combinations of independent variables to develop an acceptable regression equation for predicting the level of annual VMT in Indiana. The most acceptable equation achieved was a multiple time series with real disposable income and the relative gasoline price as independent variables. However, these two variables proved to be highly correlated and therefore the equation could not be used for future VMT estimation.

The problem of multicollinearity in such an analysis is extensive; since any variable that increases regularly with time correlates well with VMT. As a result, it was found that some independent variables accounted for as much as 98% of the VMT variance and that combinations of two or more independent variables seldom accounted for less than 99% of the VMT variance. Therefore, it was virtually impossible to isolate the causal determinants of VMT.

Another factor restricting the application of a regression model is the poor quality of existing VMT data. Traditionally, the most reliable source of VMT data has been the annual estimates provided by the Federal Highway Administration. These estimates are made on the basis of statewide fuel sales and approximations of motor vehicle fleet fuel efficiencies.

The accuracy of the VMT estimates given in Highway Statistics (1) is questionable, because a) fleet fuel efficiency estimates tend to be broad estimates, and b) states in general tend to overestimate the VMT values. The Claffey report (20), which was prepared for the FHWA, presented detailed estimates of VMT from fuel consumption reports in eight states; it was observed that the state estimates of VMT averaged 6.5 percent higher than those estimates based on the fuel consumption reports used by Claffey.

Due to the inherent problems of predicting VMT with a regression model, the total VMT estimation for the purpose of this study was made by utilizing the VMT equation developed from the first principles of elasticity by Poister, Larson, and Rao (21). The VMT estimation equation developed by Poister, et.al. is given below:

$$VMT = VMT_{1977} * (1+GR)^{i} * \left(1+EP * \frac{GPI-GPI_{base}}{GPI_{base}}\right) \qquad (4.1)$$

where

VMT = total VMT in desired year

VMT_{1977} = total VMT in base year (1977)

GR = assumed annual growth rate

i = number of years beyond base year

EP = elasticity of demand for VMT with respect to fuel price

GPI = gasoline price index (1977 = 1.00)

The above equation requires the assumption of an annual growth rate and the estimation of the demand elasticity of VMT with respect to fuel price.

The annual growth rate chosen for this analysis is 3.3 percent. A slightly higher value was chosen than the 2.5 percent annual growth rate used in the 1976 National Highway Inventory and Performance Study (5); since the 1976 study accounted for increasing fuel price in the annual growth rate considered, and subsequently, did not consider the elasticity of VMT with fuel price.

The value of -.10 was selected as the gasoline price elasticity of VMT. This value was derived from existing Indiana VMT data and the gasoline price changes along with the relevant literature (13).

Future gasoline price indices were determined by using the gas price deflator forecasts provided by the three DRI macroeconomic models (see Figure 13).

The Estimation of the Rate of Change in Commercial Vehicle-Miles of Travel

The separate estimation of commercial VMT (composed primarily of combination truck VMT) is essential as these vehicles determine, to a large extent, pavement deterioration rates. It was decided, on the basis of available data, that the future commercial vehicle VMT values could be most accurately estimated by modeling the annual rate of change in these values. This modeling procedure is described in the following paragraphs.

The technique developed for this analysis estimates future changes in commercial VMT indirectly, by assuming that the change in total commercial vehicle-miles traveled is proportional to the change in motor truck intercity ton-miles. This assumption is the basis for the following equation:

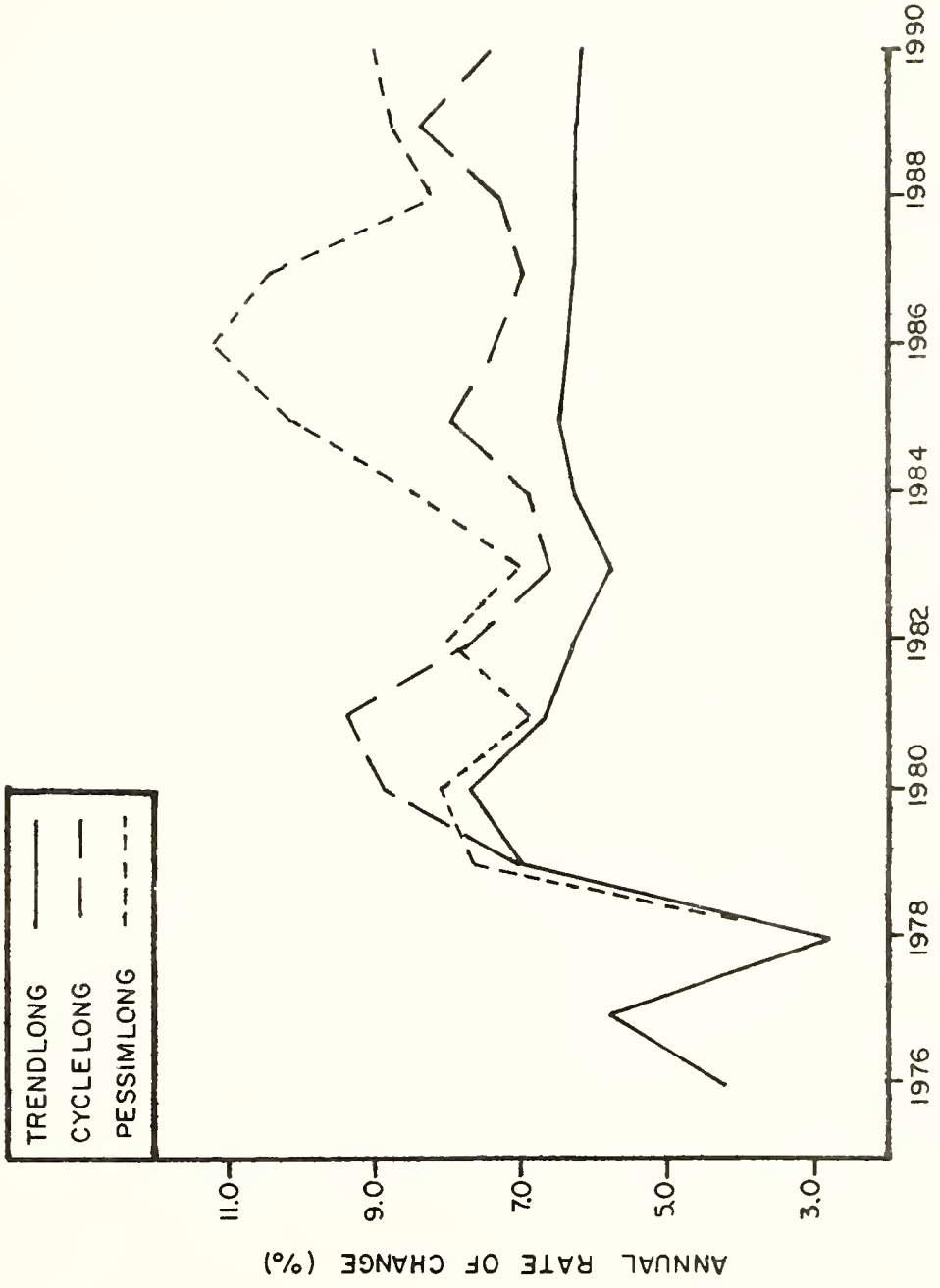

FIGURE 13. SUMMARY OF DRI GASOLINE PRICE DEFLATOR FORECASTS

$$\frac{\Delta CVMT}{CVMT} = \frac{\Delta(TITM/ALCI)}{(TITM/ALCI)} \qquad (4.2)$$

where

TITM = the motor truck intercity ton-miles

CVMT = the total commercial vehicle-miles traveled

ALCI = the average load carried index (1975 = 1.00) (includes empty and loaded trips)

This equation inherently assumes that the growth rate in intracity ton-miles will be the same as the growth rate in intercity ton-miles. Fortunately, an overwhelming percentage of total ton-miles are intercity ton-miles, and therefore, should the above assumption prove to be invalid, the overall accuracy of the projections will be affected only slightly.

The use of the above equation to estimate commercial VMT requires the projection of both motor truck intercity ton-miles and the average load carried index.

Projection of Motor Truck Intercity Ton-Miles

Several techniques have been developed in recent years to project intercity ton-miles (22). These can be classified into four basic categories: a) the regression analysis, b) econometric models (simultaneous equation systems), c) input-output models and, d) economic base studies. However, almost all of the past studies have been national in scope, and as such, do not address the unique problems encountered when attempting to project intercity ton-miles on a statewide basis. These unique problems include: 1) the non-availability of statewide motor truck intercity ton-mile data,

2) the economic interdependence between states is difficult to quantify, and 3) accurate statewide economic indicators are seldom available.

For the purpose of this study a regression approach was chosen since the lack of necessary statewide data precluded the use of econometric models, input-output models, and economic base studies. The development of a regression model necessitated the accurate approximation of past Indiana motor truck intercity ton-miles. This was achieved by multiplying national motor truck intercity ton-mile estimates by the ratio of the Indiana highway consumption of special fuels to the national highway consumption of special fuels. The highway consumption of special fuels, which constitutes all non-gasoline highway fuel consumption (diesel, LPG, and so on), is documented annually by the Federal Highway Administration. The validity of this proportion technique is based upon the fact that a large percentage of motor truck intercity ton-miles is transported by vehicles which use special fuels. The application of this technique assumes that the national truck characteristics (average load carried, fuel efficiencies, and so on) are approximately equal to the Indiana truck characteristics. This would appear to be a relatively safe assumption on the basis of existing truck characteristic data (23,24).

The following regression model was constructed using the approximated statewide motor truck intercity ton-miles.

$$\underset{\substack{\\ (-15.6)}}{TITM = -51.48} + \underset{(4.76)}{8.95 \log BI} + \underset{(3.66)}{8.72 \log SP} \qquad (4.3)$$

$$R^2 = .97 \qquad F = 265.73$$

where

TITM = Indiana truck intercity ton-miles

BI = national business index (1967 = 100.)

SP = Indiana steel production in millions of tons

The business index, which is a measure of total national industrial production, attempts to account for the economic interdependence between states. In addition, steel production was found to be a strong indicator of Indiana economic conditions and motor truck intercity ton-miles. This is due in part to the fact that steel production correlates highly with coal shipments, production of durable goods (autos, and so on), and other manufacturing activities all of which are determinants of both economic conditions and motor truck intercity shipments. Thus, the inclusion of the business index (BI) and steel production represents the logical assumption that Indiana motor truck intercity ton-mileage is a function of both state and national economic conditions.

Future business index forecasts, as provided by Data Resources Inc. (DRI), are presented in Figure 14. Figure 15 summarizes the DRI forecasts of the national steel production index. It was assumed, on the basis of recent trends and economic projections provided by other sources (12), that the Indiana steel production index would equal the nationally projected steel production index. Therefore, the actual Indiana steel production (in millions of tons) can be calculated from the following equation:

$$SP = SP_b * \frac{SPI}{SPI_b} \qquad (4.4)$$

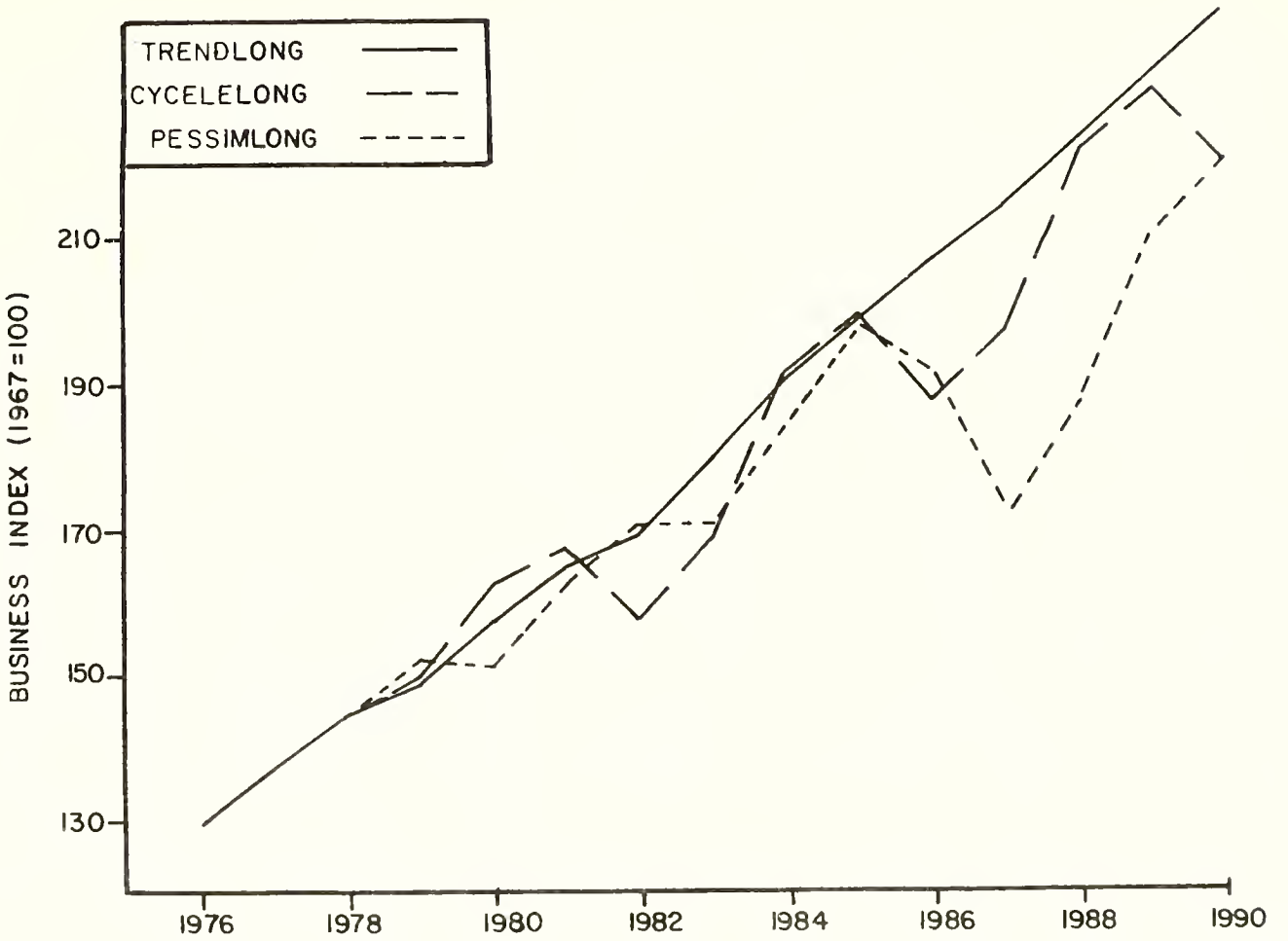

FIGURE 14.SUMMARY OF DRI INDUSTRIAL PRODUCTION (BI) FORECASTS

SOURCE: REFERENCE 7.

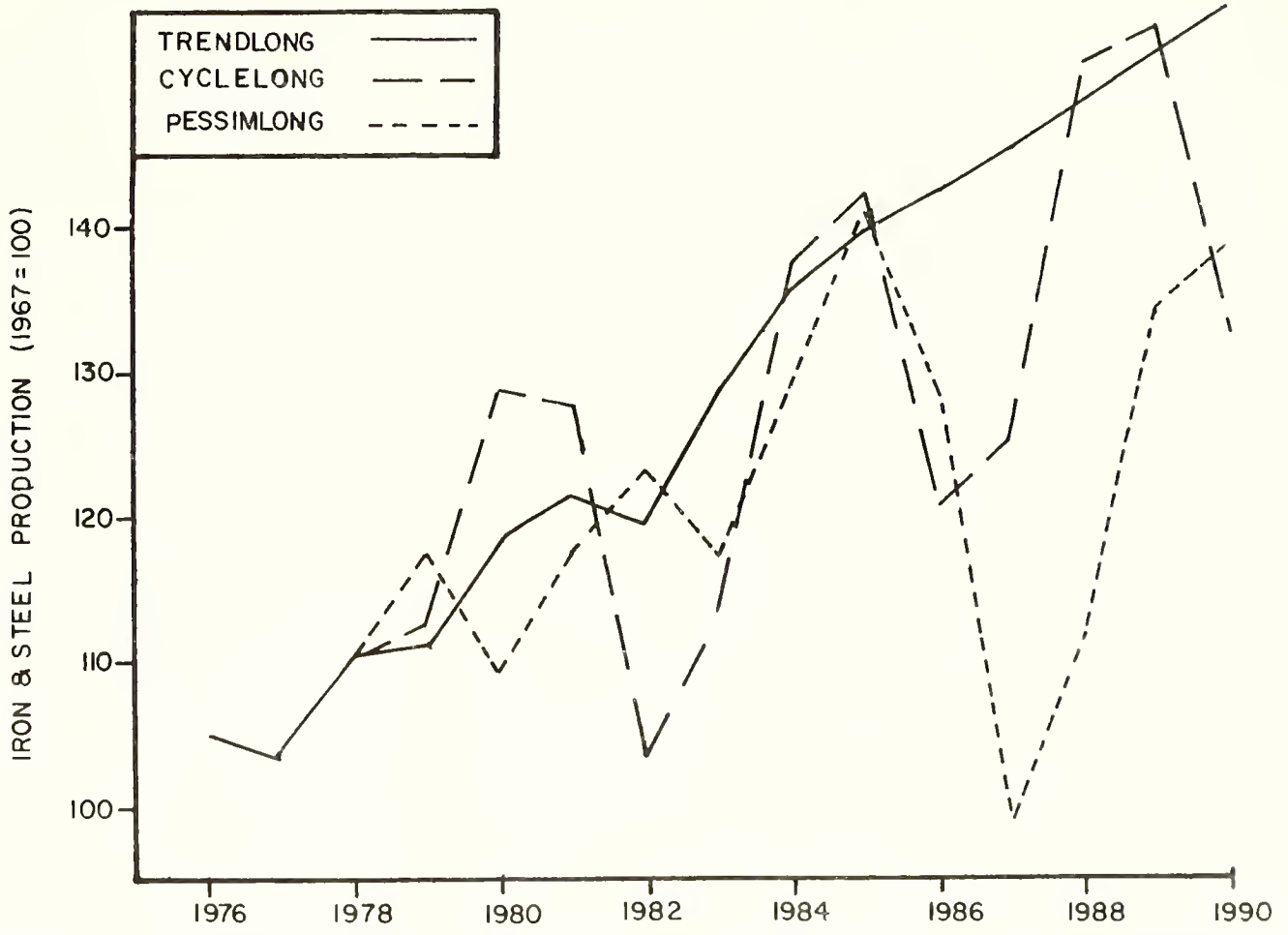

FIGURE 15. SUMMARY OF DRI NATIONAL IRON & STEEL PRODUCTION INDEX FORECASTS

SOURCE: REFERENCE 7.

where

SP = steel production in desired year

SP_b = steel production in base year

SPI = steel production index in desired year

SPI_b = steel production index in base year

Projection of Average Load Carried Index

The average load carried index is a function of a) the efficiency of the trucking industry indicating the extent of the number of empty and partially full trips, and b) the prevailing maximum weight limits.

An accurate determination of the future operating efficiency of the trucking industry is virtually impossible since future efficiencies will depend to a large extent on government policies regarding motor carrier regulations. However, an analysis of recent data has revealed that there has been no appreciable change in the percent of trucks carrying loads or the average load carried by loaded trucks (1). Subsequently, this factor was assumed to have no effect on future average load carried indices (ALCI).

Should Indiana decide to raise the maximum axle weight limits, the ALCI would obviously increase resulting in lower commercial truck VMT values (all other factors remaining constant), since less trucks would be required to move the same amount of tonnage. Estimating the extent of the ALCI change is dependent on a) the magnitude of the increase in maximum axle weight limits and b) the effect that this increase will have on truck weight distributions. An example of the calculation procedure used to estimate the ALCI when maximum axle weight limits are increased is presented in Chapter 8.

Estimation of Future VMT by Vehicle Type

Due to the fact that there is considerable variation in the fuel consumption characteristics of different vehicle types, it was necessary to segregate VMT into a) auto VMT, b) motor cycle VMT, c) bus VMT, d) single unit truck VMT, and e) combination truck VMT. This segregation was achieved by a) estimating the apportionments of total VMT constituted by each vehicle type in the base year and b) projecting future VMT values by vehicle type by applying growth rates to the above apportionments.

The apportionment of total VMT constituted by each vehicle type was determined by assuming that the national estimates of these apportionments would apply to Indiana (1). This assumption is consistent with the efforts of previous researchers (2,3).

Estimates of the future growth rates in the VMT apportionments assigned to single unit trucks, buses, and motorcycles, were made on the basis of recent trends (1) and an analysis of past studies (2,3). The resulting values are: a) a 0.5 percent annual VMT apportionment growth rate for both buses and single unit trucks, and b) a zero growth rate for motorcycle VMT apportionments.

The VMT apportionment by combination trucks was assumed to grow at the same rate as the commercial VMT growth rate (see equation 4.2), since combination trucks are almost exclusively used for commercial purposes.

Auto VMT is determined simply by subtracting the VMT apportionments of other vehicle types from the total VMT.

Calculation of Annual Fuel Consumption

Once the VMT values by vehicle type are known along with the appropriate fuel efficiencies (calculated from the previous chapter), total annual fuel consumption can be determined from the following equation:

$$AFC = \sum_{i=1}^{5} \frac{VMT_i}{FE_i} \tag{4.5}$$

where

AFC = annual fuel consumption (in gallons)

i = vehicle type (auto, bus, and so on)

VMT_i = annual vehicle-miles traveled by vehicle type i.

FE_i = average annual fuel efficiency of vehicle type i.

The annual fuel consumption values, determined from the above equation, are used as a basis to project the state motor fuel tax revenues which constitute the largest single source of Indiana state highway revenue. The procedures used to calculate motor fuel tax revenues and other state road-user revenues are discussed in the next chapter.

CHAPTER 5

REVENUE GENERATION

For this analysis, highway revenues were categorized by 1) state road user tax revenues, 2) federal road user tax revenues, and 3) non-user tax revenues which include appropriations from general funds. Federal road user tax revenues include those revenues collected by federal agencies from federal taxes on fuel, lubricating oil, motor vehicles, tires, vehicle parts and accessories, and motor vehicle usage. Non-user revenues are derived from such sources as property taxes, bond proceeds, appropriations from general funds, and other miscellaneous non-user receipts. An accurate projection of non-user taxes and the portion of federal road user taxes being returned to the state is difficult to obtain, due to the fact that the projection of funds from these sources depends to a large extent upon future legislative decisions which can vary considerably. As a result, revenue estimations from these sources are determined exogenously. A description of the procedure used for such determinations is presented in Chapter 8.

The revenues derived from state user taxes can be readily calculated once estimates of future tax and fee rates and projections of revenue sources are made. A set of possible future tax and fee rates was considered which were then used in various model runs. Revenue

sources were projected by classifying state user-tax revenues into four basic sources: 1) revenues derived from motor vehicle registrations, 2) revenues derived from license fees, 3) revenues derived from state taxes on motor fuel and, 4) revenues derived from miscellaneous user sources.

Projected Motor Vehicle Registrations

Registration projections were made under the following assumptions:

1. Motorcycle registrations, bus registrations, and single-unit truck registrations (which are comprised mainly of privately owned pickups and vans) will be proportional to future auto registrations.
2. Combination truck registrations will be independent of auto registrations and influenced by prevailing economic conditions.

Auto Registration Projections

Although the DRI macroeconomic forecasts provided nationwide auto ownership projections, the Indiana auto ownership estimates could not be made as a proportion to national auto ownership, because of differential growth rates observed in historical data (1). As a result, a separate procedure was developed to predict automobile registrations in Indiana.

In an attempt to develop an appropriate regression equation the problem of multi-collinearity among independent variables made the task of isolating causal determinants impossible. Previous researchers (25) have developed regression equations to predict auto

ownership using real disposable income as the independent variable. Although pre-1974 data would appear to substantiate these equations; the data of recent years renders the validity of such an approach questionable as the observed decrease in real disposable income has had virtually no effect on auto ownership trends (1). It is therefore reasonable to suggest that auto ownership is determined by a far more complex behavioral choice process than the simple income model.

Due to the absence of data necessary to simulate the actual behavioral choice process that determines auto ownership, an alternative technique was adopted. This technique, utilized in a number of previous studies (2,15,26) assumes that an automobile saturation will be reached at which time the number of vehicles per capita will stabilize. This assumption seems reasonable since the current rate of increase in per capita ownership cannot be expected to continue indefinitely. However, establishing the point at which per capita ownership will stabilize was somewhat subjective as there was little evidence of such stabilization trends in existing data. The saturation value of .6 autos (in use) per capita to be achieved in the year 2000 was used in the present analysis. This value is comparable to the values selected by other researchers (2,26).

Once the saturation value was established, a power curve was fitted to the original data so that annual estimates of per capita auto ownership could be made. The equation used assumes the following form:

$$Y = S + K(100 - X)^{P} \qquad (5.1)$$

where

Y = projected persons per auto in a given year.

S = projected saturation point for the year 2000.

K = constant determined through curve fitting.

X = last two digits of a given year.

P = exponent determined through curve fitting.

Once the number of persons per auto is established from the above equation, estimates of future Indiana auto registrations can be readily calculated providing statewide population projections are made.

Statewide Population Projections

In this study, the cohort survival method was used to project statewide population. This method accounts for births, deaths, and adjusts for migration. The projection was achieved by dividing the total population into 16 male and female age groups considered in five year increments. The initial number in each of the five year cohorts was obtained from data presented in the 1970 U.S. Census.

The future survival rates, which are defined as the probability of a cohort member surviving to the succeeding cohort, were taken directly from the estimates presented by the Bureau of the Census (27). The bureau also provides low, intermediate and high estimates of future cohort fertility rates. The future fertility rates used in this study (see Table 9) were assumed to be between the low and intermediate estimates so as to be consistent with recent fertility rate trends.

Indiana has experienced a relatively high net outward migration in recent years. Since the exodus of industry and population to the

sunbelt states is expected to continue well into the future, net outward migration can be assumed to persist over the time period of this analysis. However, the magnitude of this outward migration was projected to decrease over time, due to the fact that economic conditions in Indiana are expected to compare favorably to those of other industrial states. The estimated migration rates are presented in Table 10.

Population projections using five year cohorts can be made only at five year intervals, therefore, linear extrapolation was used to obtain intermediate annual estimates. Table 11 presents the results of the cohort method using the survival, fertility, and migration rates described above. These results tend to be lower than those estimated by other studies (2,3,28). This is due largely to the fact that previous studies have under-estimated the actual net outward migration in Indiana from 1970-1975.

The number of registered autos in any given year can be estimated simply by dividing the appropriate annual state population by the corresponding persons per auto determined from Equation 5.1. The results obtained for the state using the saturation procedure used in this study were observed to be consistent with the DRI national auto ownership projections.

Truck, Bus, and Motorcycle Registrations

Projections of single-unit truck registrations and bus registrations were made by multiplying auto registrations by an appropriate factor which was derived from recent registration data. Growth rates

TABLE 9. ESTIMATED ANNUAL FERTILITY RATES PER 1000 WOMEN OF CHILD-BEARING AGE (15-49) IN INDIANA.

YEARS	FERTILITY RATE
1970-1975	71.5
1975-1980	70.0
1980-1985	69.1
1985-1990	67.1

TABLE 10. ESTIMATED NET MIGRATION FOR INDIANA (IN PERCENT OF POPULATION).

YEARS	MALE	FEMALE
1970-1975	-1.90	-1.71
1975-1980	-2.21	-2.00
1980-1985	-0.95	-0.86
1985-1990	-0.53	-0.48

TABLE 11. INDIANA POPULATION PROJECTIONS TO 1990.

YEAR	FEMALE	MALE	TOTAL
1976	2721213	2583408	5304622
1977	2724349	2585777	5310128
1978	2734861	2595147	5330011
1979	2753609	2612330	5365943
1980	2776940	2633871	5410811
1981	2794016	2650734	5444751
1982	2811092	2667597	5478691
1983	2828168	2684460	5512631
1984	2845244	2701323	5546571
1985	2862323	2718189	5580512
1986	2880076	2736110	5616187
1987	2897829	2754031	5651862
1988	2915582	2771952	5687537
1989	2933335	2789873	5723212
1990	2951091	2807798	5758889

for these factors were applied to single-unit truck registrations (.5 percent per annum) and bus registrations (.05 percent per annum). These growth rates were determined from observed trends in state registration data (1). The projection equation assumed the following form:

$$XREG = PRP_{base} * (1 + GRP)^{i} * AREG \qquad (5.2)$$

where

XREG = the registration estimate by vehicle type in the desired year.

PRP_{base} = the ratio of registration by vehicle type to auto registration in the base year.

GRP = the assumed growth rate in the ratio described above.

AREG = total auto registration in the desired year.

Motorcycle registrations were assumed to remain at the same proportion to auto registration (i.e., GRP = 0) over the time period of this analysis. Table 12 summarizes the registration projections achieved using the above techniques.

The number of combination trucks being registered in any given year is dependent, to some extent, upon economic conditions, since combination trucks are used almost exclusively for commercial purposes. Problems of multicollinearity among independent variables precluded the use of a regression analysis involving a detailed evaluation of the causal variables. Future combination truck registrations were estimated by assuming a growth rate and an elasticity of demand for registrations with respect to the business

TABLE 12. SUMMARY OF INDIANA MOTOR VEHICLE REGISTRATION PROJECTIONS.

YEAR	AUTO REGISTRATIONS	SINGLE UNIT TRUCK REGISTRATIONS	BUS REGISTRATIONS	MOTORCYCLE REGISTRATIONS
1976	2652311	719703	14860	145877
1977	2713495	739987	15210	149242
1978	2759177	756207	15474	151754
1979	2803721	772258	15732	154204
1980	2847795	788320	15987	156628
1981	2882846	802012	16192	158556
1982	2915602	815181	16384	160358
1983	2946675	827988	16567	162067
1984	2976460	840538	16743	163705
1985	3005231	852907	16913	165288
1986	3034119	865406	17084	166876
1987	3062337	877823	17251	168428
1988	3089993	885750	17416	169949
1989	3117173	898009	17578	171445
1990	3143945	910249	17738	172917

index (which is a measure of industrial production and a strong indicator of economic conditions). The following equation was used to project combination truck registrations:

$$CTR = CTR_{base}(1+GR)^{i} * \left(1+EP * \frac{(BI-BI_{base})}{BI_{base}}\right) \qquad (5.3)$$

where

CTR = combination truck registrations in the desired year.

GR = assumed growth rate in combination truck registrations.

i = number of years beyond the base year.

EP = elasticity of demand for registrations with respect to the business index.

BI = business index (1967 = 100).

The elasticity of the demand for registrations with respect to the business index was determined to be +.24. This value was derived from a number of multiple time series regressions, which were run using data from the past 15 years (1). A growth rate of 1.5 percent per annum was chosen for the time period of this analysis. This growth rate was determined by discounting the observed Indiana combination truck registration growth rate trends, which have averaged 2.5 percent annually over the past 15 years.

Review of the Current Indiana Motor Vehicle Registration Fee Structure

The current registration fees in Indiana are $12 for passenger cars, $16 for school and church buses, and $6 for motorcycles. Truck registration fees are assessed on the basis of gross vehicle weight.

It was assumed in the present study that the Indiana gross vehicle weight distributions of trucks would remain constant over the time period of this analysis and would equal the observed 1975 Indiana weight distributions of trucks. The only exception to this assumption occurs when an increase in permissible truck weight limits is considered; the effects of this consideration will be described in Chapter 8. The 1975 Indiana truck weight distributions, obtained from the 1975 Highway Statistics (1) are summarized in Table 13.

The current fee structure for trucks and private buses is outlined in Table 14.

Projected Number of Licensed Drivers

Projections of the number of licensed drivers were performed by estimating the ratio of licensed drivers per 1,000 driving age population (15 years and over). The driving age population was obtained from the cohort population projection described earlier.

The Indiana ratio of licensed drivers per 1,000 driving age population has increased steadily until the late 1960's from which time fluctuations have been evidenced with a general upward trend. It can be expected that the growth in this ratio would be small over the time period of this analysis. This decreased growth can be attributed to 1) the anticipated increase in auto costs, 2) the decreased growth rate in per capita auto ownership, and 3) the anticipated increase in transit usage.

Table 15 presents past and projected ratios of licensed drivers per 1,000 driving age population.

TABLE 13. INDIANA PERCENTAGE OF TOTAL TRUCKS BY TRUCK TYPE AND WEIGHT CATEGORY.

GROSS WEIGHT NOT EXCEEDING (LBS)	SINGLE UNIT TRUCKS	TRACTOR TRUCKS
7000	78.0	0.0
9000	3.1	0.0
11000	5.2	0.0
16000	4.1	0.0
20000	2.6	1.5
26000	5.0	0.8
30000	1.1	1.3
36000	0.3	1.9
42000	0.5	3.9
48000	0.5	3.0
54000	0.2	5.6
60000	0.0	12.8
66000	0.1	2.1
72000	1/ 0.3	11.4
72000 AND OVER	-	55.7

1/ INCLUDES ALL VEHICLES WITH WEIGHTS OF 66,001 POUNDS AND OVER

SOURCE: REFERENCE 1.

TABLE 14. INDIANA MOTOR TRUCK REGISTRATION FEES (IN DOLLARS)

GROSS WEIGHT NOT EXCEEDING (LBS)	SINGLE UNIT TRUCKS AND BUSES	TRACTOR TRUCKS W/ SEMITRAILERS
7000	16	-
9000	24	-
11000	40	-
16000	65	-
20000	100	110
26000	120	190
30000	175	235
36000	225	285
42000	275	310
48000	325	360
54000	375	385
60000	400	410
66000	425	435
72000	1/ 450	485
72000 AND OVER	-	500

1/ INCLUDES ALL VEHICLES WITH WEIGHTS OF 66,001 POUNDS AND OVER

SOURCE: REFERENCE 3.

TABLE 15. SUMMARY OF RATIOS OF LICENSED DRIVERS PER 1000 DRIVING AGE POPULATION.

YEAR	LICENSED DRIVERS PER 1000 DRIVING AGE POPULATION
1950	583
1955	699
1960	720
1965	807
1970	735
1975	851
1980	860
1985	868
1990	877

Projected Net Tax Revenues From Motor Fuel Consumption

The motor fuel consumption model, discussed earlier, provides estimates of annual motor fuel consumption from which gross fuel tax revenues can be calculated simply by multiplying the total gallonage of fuel consumed by a given fuel tax rate. The net fuel tax revenues can then be computed by subtracting motor fuel refunds (originating from such sources as evaporation, spillage, and non-highway use tax compensation) from the gross fuel tax revenues. These refunds have historically averaged 3 percent of the gross fuel tax revenues and, for projection purposes, it was assumed that this value would apply over the time period of this analysis. The following equation was then used to calculate net fuel tax revenues.

$$NFR = 0.97 * MFC * TR$$

where

NFR = net fuel tax revenues

MFC = total motor fuel consumption

TR = given tax rate.

Projections of Revenue from Miscellaneous Sources

Miscellaneous sources include such items as chauffeur licenses, distributor licenses, and a variety of other motor fuel and vehicle sources. The individual projection of such sources would be a difficult and tedious task. Fortunately, the amount of revenue derived from miscellaneous sources has remained almost constant, in recent years, at 8 percent of the total state user tax revenues.

Therefore, for projection purposes, revenues from miscellaneous sources were accounted for by adding 8 percent to the sum of the revenues derived from motor fuel taxes, vehicle registrations, and driver licenses. The same approach was used by McCarthy in an earlier study (2).

CHAPTER 6

HIGHWAY PERFORMANCE

In this study, the relative performance of highway sections was considered by functional classification (e.g. interstate, arterial, collector, and so on) and it was measured in terms of a "condition index". The condition indices were scaled from 0 to 100 and they are derived by appropriately weighting relevant highway characteristics. The characteristics used to determine such an index are components of the following elements:

1. Condition - this element reflects the structural status of the roadway and is determined by such factors as the type of pavement and the pavement condition.
2. Service - the service element is a measure of traffic congestion during peak periods and is an indicator of the level of service provided by the roadway under such conditions. Highway characteristics such as peak-hour volume/capacity ratios and peak-hour operating speeds are used to evaluate this element.
3. Safety - this element is an assessment of the accident potential of the roadway. An estimate of this index is made on the basis of features such as lane widths and right shoulder widths.

The initial values of the condition indices were approximated indirectly using statewide data provided in the 1976 National Highway Inventory and Performance Study (NHIPS) (5). Tables 16 through 18 summarize the Indiana data available from this source. It should be noted that the 1976 NHIPS data is categorized by rural, urban, and small urban highway functional classifications due to the inherent variability in design standards and travel characteristics between such systems.

Descriptions of the functional systems, as defined by the FHWA publication, "Highway Functional Classification, concepts, criteria, and Procedures" (29) are as follows:

1) Principal Arterial System -- In rural areas, a network of routes that primarily serves travel of statewide or interstate significance; serves virtually all urban areas over 50,000 population; provides high overall travel speed with minimum interference to through activity; serves the highest traffic volume corridors and the longest trip lengths; and carries a high proportion of urban area travel.

The principal arterial system is substratified as follows: 1) interstate; 2) other freeways and expressways (in urban areas only); and 3) other principal arterials.

2) Minor Arterial System -- In rural areas, a network of routes which provides access to principal arterial routes, and in conjunction with principal arterials, forms a network which links cities and larger towns to facilitate interstate and intercounty service.

In urban areas, this system provides service to trips of moderate length at a somewhat lower level of travel mobility. Such routes interconnect with and augment the principal arterial system. They may carry local bus routes and provide intra community connectivity.

3) Collector Systems -- In rural areas, a network of routes which generally serves travel of a more localized nature rather than statewide importance and on which predominant travel distances are shorter than on arterial routes. The collector system is stratified as follows: 1) major collectors - serving county seats and other traffic generators not directly served by arterial routes; and 2) minor collectors - linking locally important traffic generators with smaller communities.

TABLE 16. 1975 RURAL HIGHWAY SUMMARY BY FUNCTIONAL CLASSIFICATION.

(IN PERCENTS)

	INTERSTATE		OTHER PRIN ART		MINOR ARTERIAL		MAJOR COLLECTOR		MINOR COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	48	70	7	15
INTERM	0	0	0	0	0	0	42	25	74	72
LOW	0	0	0	0	0	0	9	5	19	13
PAVEMENT CONDITION: 1/										
POOR	1	1	1	1	0	0	4	6	7	5
FAIR	20	18	29	31	38	43	47	45	66	59
GOOD	80	82	69	67	61	57	49	49	27	37
VOL/CAP RATIOS: 2/										
< .31	55	37	71	73	75	58	98	92	100	97
.31 - .80	45	63	28	23	25	41	2	8	0	3
> .80	0	0	1	3	0	1	0	0	0	0
LANE WIDTH (FT):										
< 10	0	0	0	0	0	0	30	20	64	56
10 - 11	0	0	17	17	36	32	58	59	34	38
> 11	100	100	83	83	64	68	12	21	2	6

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

SOURCE: REFERENCE 5.

TABLE 17. 1975 URBAN HIGHWAY SUMMARY BY FUNCTIONAL CLASSIFICATION.

(IN PERCENTS)

	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	86	85	38	51	17	15
INTERM	0	0	0	0	14	15	62	49	81	85
LOW	0	0	0	0	0	0	0	0	1	1
PAVEMENT CONDITION: 1/										
POOR	0	0	0	0	1	1	2	2	7	6
FAIR	10	5	6	9	50	49	42	43	44	40
GOOD	90	95	94	91	49	50	56	55	49	54
VOL/CAP RATIOS: 2/										
< .31	21	8	73	59	27	15	35	24	75	55
.31 - .90	69	71	24	41	49	44	48	47	21	37
> .90	10	20	3	0	24	41	17	29	4	8
LANE WIDTH (FT):										
< 10	0	0	0	0	8	8	13	14	23	15
10 - 11	0	0	5	9	27	29	44	44	48	62
> 11	100	100	95	91	64	63	43	43	28	24

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

SOURCE: REFERENCE 5.

TABLE 18. 1975 SMALL URBAN HIGHWAY SUMMARY BY FUNCTIONAL CLASSIFICATION.

(IN PERCENTS)

	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	96	95	42	50	21	29
INTERM	0	0	0	0	4	5	58	50	77	69
LOW	0	0	0	0	0	0	0	0	3	3
PAVEMENT CONDITION: 1/										
POOR	0	0	0	0	0	0	6	4	9	9
FAIR	0	0	8	10	54	53	49	45	51	45
GOOD	100	100	92	90	46	46	45	51	40	46
VOL/CAP RATIOS: 2/										
< .31	17	9	78	77	29	19	48	36	90	85
.31 - .90	83	91	22	23	63	67	42	53	10	15
> .90	0	0	0	0	9	13	10	11	0	0
LANE WIDTH (FT):										
< 10	0	0	0	0	11	13	15	11	31	23
10 - 11	0	0	0	0	22	22	40	42	33	36
> 11	100	100	100	100	67	66	45	47	36	41

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.

SOURCE: REFERENCE 5.

In urban areas, such routes distribute trips to and from the arterials to their ultimate destinations. Such routes provide for local traffic movement within residential neighborhoods, commercial areas, and industrial areas.

The highway functional classifications described above have been standardized since the early 1970's and they provide a practical level of aggregation for the purpose of system analysis.

The highway characteristics used in the present study to evaluate the condition, service, and safety elements are: 1) pavement type, 2) pavement condition, 3) peak-hour volume/capacity ratio and, 4) lane width. The impact that the above characteristics have on the condition index vary according to rural and urban systems and functional classifications. The weights assigned to the three elements and their components were derived from the 1976 NHIPS and are shown in Table 19.

The variation in the condition index weights reflects the difference between service oriented high volume facilities and condition oriented high speed facilities. In most cases the safety element, represented by lane widths, is given equal importance, and subsequently, was assigned the same weighting regardless of the type of facility.

Regretably, the highway characteristic data provided by the 1976 NHIPS (Tables 16-18) is not nearly detailed enough to be used as a basis for projecting highway condition indices, and therefore, it was necessary to devise a procedure that would provide the level of aggregation necessary for such projections.

Procedure to Estimate Present Highway Performance

A Monte Carlo sampling technique was used to create a sample of roadway sections which were categorized by highway functional classification.

TABLE 19. URBAN AND RURAL CONDITION INDEX WEIGHTS BY FUNCTIONAL CLASSIFICATION.

URBAN WEIGHTS

	PRINCIPAL ARTERIALS	MINOR ARTERIALS	COLLECTORS
CONDITION:			
PAVEMENT TYPE	10	10	10
PAVEMENT COND.	30	35	40
SERVICE:			
VOL/CAP RATIO	40	30	20
SAFETY:			
LANE WIDTH	20	25	30

RURAL WEIGHTS

	PRINCIPAL ARTERIALS	MINOR ARTERIALS	COLLECTORS
CONDITION:			
PAVEMENT TYPE	10	10	10
PAVEMENT COND.	30	40	50
SERVICE:			
VOL/CAP RATIO	40	30	20
SAFETY:			
LANE WIDTH	20	20	20

Each of the roadway sections was assigned a set of attributes which were then used to project the four basic determinants of the condition index: pavement type, pavement condition, volume/capacity ratio, and lane width. The section attributes were: 1) section length, 2) traffic volume, 3) number of lanes, 4) pavement thickness, 5) pavement condition, 6) peak-hour volume/capacity ratio and 7) lane width. An explanation as to how these attributes were assigned is given below.

Section Lengths - Highway section lengths are used to determine future maintenance and construction costs which are estimated on a per mile basis. The number of section lengths assigned are governed, in most cases, by computer memory limitations which restrict the number of sections to 100 for each functional classification. The minimum section length was chosen to be 2 miles, since it was felt that smaller lengths would provide an unrealistic variation in highway attributes among functional classifications with small mileages. Therefore, in most instances, the section length is determined by dividing the functional classification system mileage by 100. However, in those cases when the resultant value is less than 2 miles, the section length is set at 2 miles and the number of sections representing that functional classification is reduced accordingly. Table 20 summarizes the 1975 Indiana system mileage and daily vehicle miles traveled by functional classification.

Traffic Volumes - Traffic volumes are used to project peak-hour volume/capacity ratios and pavement conditions. Section traffic volumes were determined by assuming that the average daily traffic (ADT) volumes can be approximated by a normal distribution within each

TABLE 20. 1975 INDIANA HIGHWAY SYSTEM MILEAGE AND DAILY VMT.

	MILEAGE	DAILY-VMT (THOUSANDS)
RURAL:		
INTERSTATE	827	11330
OTHER PRIN ART	1048	4972
MINOR ARTERIALS	3032	13131
MAJOR COLLECTORS	8724	8829
MINOR COLLECTORS	11332	2572
URBAN:		
INTERSTATE	210	7718
OTH FWY & EXPWY	67	946
OTHER PRIN ART	781	11182
MINOR ARTERIALS	1526	9500
COLLECTORS	1183	2794
SMALL URBAN:		
INTERSTATE	27	608
OTH FWY & EXPWY	52	173
OTHER PRIN ART	512	4284
MINOR ARTERIALS	733	3291
COLLECTORS	614	959

SOURCE: REFERENCE 5.

functional classification. The average ADT's and their corresponding standard deviations were estimated from the 1975 traffic map of Indiana which was prepared by the Division of Planning of the Indiana State Highway Commission. Table 21 summarizes the average 1975 ADT's and their standard deviations for each functional classification.

Once the average ADT's and their attendant standard deviations have been established, the traffic volume on each randomly sampled roadway section was assigned by generating a series of normally distributed random numbers with the specified mean and standard deviation. Minimum volumes were set to prevent the possibility of negative or unrealistically low values.

Number of Lanes - This attribute will influence future pavement conditions and peak-hour volume/capacity ratios. The number of lanes assigned to each roadway section was determined by first, assuming an appropriate peak-hour factor (as shown in Table 24) which when multiplied by the average daily traffic volume provides an approximation of one direction peak-hour volumes, and second, estimating the maximum per lane hourly capacity (30). Once the above estimations are made, the number of lanes in each direction is simply equal to the resultant of the one direction peak-hour volume divided by the lane capacity. This value is appropriately rounded off to provide an integer value.

Pavement Thickness - Pavement thickness is used directly to represent the pavement structure quality, which is a significant component of the condition index. In this analysis, pavements were classified as high type (all rigid pavements or flexible pavements

TABLE 21. 1975 INDIANA AVERAGE ADT'S AND STANDARD DEVIATIONS BY FUNCTIONAL CLASSIFICATION.

	AVERAGE ADT	STANDARD DEVIATION
RURAL:		
INTERSTATE	16400	6650
OTHER PRIN ART	5700	3500
MINOR ARTERIALS	5200	3300
MAJOR COLLECTORS	1200	600
MINOR COLLECTORS	600	230
URBAN:		
INTERSTATE	44000	16000
OTH FWY & EXPWY	16900	7200
OTHER PRIN ART	17200	7500
MINOR ARTERIALS	7460	3100
COLLECTORS	2830	1700
SMALL URBAN:		
INTERSTATE	27020	10800
OTH FWY & EXPWY	4000	1800
OTHER PRIN ART	10000	5100
MINOR ARTERIALS	5400	3000
COLLECTORS	1870	1000

with a thickness index greater than 3.1 inches), intermediate type (flexible pavements with a thickness index greater than 2.6 inches and less than 3.1 inches), and low type (flexible pavements with a thickness index less than 2.6 inches or unpaved facilities). This classification was done only to simplify the computer model output, and the actual thickness indices or slab thicknesses (in the case of rigid pavements) were used in the condition index computations.

The thickness index for flexible pavements was defined by the following equation.

$$TI = .44D_1 + .14D_2 + .11D_3 \qquad (6.1)$$

where

TI = thickness index

D_1 = surfacing thickness, inches

D_2 = base thickness, inches

D_3 = subbase thickness, inches

For rigid pavements, the slab thickness alone was used and these values were estimated by utilizing the summary of Indiana rigid pavement depths presented in reference 31.

The values for flexible pavement thickness indices were determined using daily truck volumes as a criterion. The truck volumes on each roadway section were calculated using data available from the 1975 national truck characteristics report (24) in which ratios of the truck volume to total vehicle volume are presented and categorized by highway functional classification. Once the truck volumes on each roadway section were established, an appropriate thickness index was

selected using a procedure similar to the group-index method, which is widely used in flexible pavement design (31).

Pavement Condition - The present pavement conditions will directly affect future pavement conditions since the present conditions along with the pavement thickness determine the number of additional axial loads the pavement can sustain. Pavement conditions are measured by using the present serviceability rating (PSR). The PSR values range from 5.0 for new pavements to 0.0 for completely deteriorated pavements. The 1976 NHIPS data categorizes pavement conditions into good (PSR=3.4 to 5.0), fair (PSR=2.5 to 3.4 for principal arterials and PSR=2.0 to 3.4 for other classifications), and poor (PSR<2.5 for principal arterials and PSR<2.0 for other classifications). It was assumed that such values are uniformly distributed within each of the three categories of pavement condition. The assignment of PSR values then was made by generating a series of uniformly distributed random numbers which in turn was used to; 1) select good, fair, or poor categories with the probability of selection equal to the proportion of mileage in each category and, 2) select a specific PSR value with equal probability within each category.

Peak-Hour Volume/Capacity Ratios - The peak-hour volume/capacity ratios (V/C) are used exclusively to measure the service element, and subsequently, play an important role in the determination of the condition index. The 1976 NHIPS data provides three broad categories of peak-hour V/C ratios. The assignment of V/C ratios to individual roadway sections is done assuming that the V/C ratios are uniformly distributed within each category. However in this case, there exists

the fact that high volume sections are more likely to have high V/C ratios than low volume sections and, therefore, the probability of selecting a V/C category was assumed to be a function of the ratio, percent mileage/percent volume, for each category. The selection of specific V/C ratios within each category was done with uniform probability as was the case with pavement conditions.

Lane Widths - The lane widths are used to represent the safety element of the roadway. The 1976 NHIPS data categorizes lane widths into; 1) less than 10 feet, 2) 10 to 11 feet, and 3) greater than 11 feet. It was assumed that lane widths would be uniformly distributed within each of the above categories. A minimum lane width of 9 feet and a maximum lane width of 12 feet were applied to the first and third categories respectively. Individual lane widths were then determined using the same random sampling approach as that used for the assignment of pavement conditions. The interstate systems were excluded from the approach described above as all of these facilities exclusively have 12 feet lane widths and were so assigned.

Estimation of Future Highway Performance

Future highway performance was estimated simply by projecting the seven attributes assigned to each roadway section. Attributes such as the number of lanes, pavement thickness, and lane widths will remain constant unless appropriate construction is performed on the roadway section. If no reconstruction is performed on a given section, the attributes that will change in the future are: 1) section length, 2) traffic volume, 3) peak-hour volume/capacity ratio, and 4) pavement condition.

Projection of Section Lengths - From year to year there are changes in the system mileages of each functional classification. These changes are induced by urban growth which results in the transfer of mileage from rural to urban systems, the upgrading of facilities to higher classifications, and the growth in total highway mileage. The estimation of the extent of annual fluctuations in functional classification system mileage is achieved by approximating 1990 system mileages and assuming a uniform annual growth rate between 1975 and 1990. The 1990 system mileages were derived using a number of sources (3, 32, 33), and are presented along with the annual growth rates in Table 22. Once the growth rates are known, the annual system mileages are calculated and the section lengths of each functional classification are increased or decreased such that the summation of the section lengths is equal to the calculated classification mileages.

Projections of Traffic Volumes - Future traffic volumes were estimated under the assumption that the growth in traffic volume would be proportional to the growth in the vehicle-miles of travel (VMT) per mile of highway. This assumption is illustrated by the following equation:

$$PGRV = \frac{\frac{FVMT}{FSM} - \frac{FVMT_{-1}}{FSM_{-1}}}{\frac{FVMT_{-1}}{FSM_{-1}}} \times 100 \qquad (6.2)$$

where

PGRV = percent growth in functional system volumes.

FVMT = functional system VMT in desired year.

$FVMT_{-1}$ = functional system VMT in preceding year.

TABLE 22. 1990 INDIANA HIGHWAY SYSTEM MILEAGE AND TOTAL 1975 TO 1990 MILEAGE GROWTH RATES

	MILEAGE	MILEAGE GROWTH RATE (PERCENT)
RURAL:		
INTERSTATE	869	5.0
OTHER PRIN ART	1170	11.6
MINOR ARTERIALS	3100	2.2
MAJOR COLLECTORS	8700	-0.3
MINOR COLLECTORS	11250	-0.7
URBAN:		
INTERSTATE	225	7.1
OTH FWY & EXPWY	119	77.6
OTHER PRIN ART	897	14.9
MINOR ARTERIALS	1635	7.1
COLLECTORS	1225	3.6
SMALL URBAN:		
INTERSTATE	35	29.7
OTH FWY & EXPWY	77	48.1
OTHER PRIN ART	609	18.9
MINOR ARTERIALS	839	14.5
COLLECTORS	656	6.8

FSM = functional system mileage in desired year.

FSM_{-1} = functional system mileage in preceding year.

The functional system mileages are known during each year from the uniform annual growth rate assumption made earlier (see Table 22). However, it was necessary to develop a technique to determine VMT values by functional classification (FVMT in Equation 6.2).

Since the growth in the total highway system VMT can be obtained from the VMT equation used in the fuel consumption model, a logical solution to the problem of determining functional system VMT values is to apply a proportion of individual functional system VMT growth to total system VMT growth. These proportions were developed by using the 1976 NHIPS estimates of 1990 VMT by functional classification to calculate annual VMT growth rates from 1975 to 1990 (assuming uniform growth) on each functional classification. The division of these growth rates by the average annual growth rate of the entire system mileage resulted in the desired growth rate proportions. These values are presented in Table 23.

Once these proportions are known, the VMT of each functional classification can be determined by applying the following equation:

$$FVMT = FVMT_{-1} * (PR * \frac{\Delta TVMT}{TVMT_{-1}} + 1) \qquad (6.3)$$

where

FVMT = functional system VMT in desired year.

$FVMT_{-1}$ = functional system VMT in preceding year.

PR = proportion of functional system VMT growth to total VMT growth.

TABLE 23. VMT GROWTH RATE PROPORTIONS BY FUNCTIONAL CLASSIFICATION.

	GROWTH RATE PROPORTION
RURAL:	
INTERSTATE	0.80
OTHER PRIN ART	1.00
MINOR ARTERIALS	0.72
MAJOR COLLECTORS	0.64
MINOR COLLECTORS	0.64
URBAN:	
INTERSTATE	1.32
OTH FWY & EXPWY	2.16
OTHER PRIN ART	1.12
MINOR ARTERIALS	1.12
COLLECTORS	1.02
SMALL URBAN:	
INTERSTATE	1.00
OTH FWY & EXPWY	1.24
OTHER PRIN ART	1.00
MINOR ARTERIALS	1.02
COLLECTORS	1.02

$\Delta TVMT$ = change in total system VMT.

$TVMT_{-1}$ = total system VMT in preceding year.

Should there be a case where the system VMT values decline, the reciprocals of the growth rate proportions shown in Table 23 would be used as PR in Equation 6.3. This assures that high growth systems will have lower loss rates should such a situation arise.

The traffic volume growth rates on each functional classification are now known from Equation 6.2. The only remaining task is to determine the volume growth rates on individual highway sections within each functional classification. This was done by generating a series of normally distributed random numbers with a mean of 0.0 and a standard deviation of 1.5 percent and adding these numbers to the volume growth rates of each functional classification. This procedure provides a distribution of growth rates that is compatible with historical growth rate distributions (30). The standard deviation value of 1.5 percent was chosen to be consistent with the 3.3 percent growth rate used in the VMT equation discussed earlier.

Projection of Peak-Hour Volume/Capacity Ratios - Although the peak-hour volume/capacity ratios (V/C) can be assigned to roadway sections using the technique previously described, an estimation of peak-hour volumes and hourly capacities are necessary for the projection of V/C ratios.

Peak-hour volumes were approximated using the percentage of average daily volumes occurring in the peak-hour as a basis. The initial values of this percentage are shown in Table 24 (30). It must be realized that the values shown in Table 24 are generalized

TABLE 24. PERCENTAGE OF THE AVERAGE DAILY VOLUME IN PEAK HOUR.

TYPE OF FACILITY	PERCENTAGE IN PEAK HOUR (ONE DIRECTION)
RURAL:	
FREEWAY	23.6
EXPRESSWAY	21.5
HIGHWAY WITH MORE THAN 2 LANES	21.2
2 LANE TWO WAY HIGHWAY	23.0
URBAN:	
FREEWAY	15.0
EXPRESSWAY	14.6
STREET WITH MORE THAN 2 LANES	13.8
2 LANE TWO WAY STREET	14.8

and the actual values will naturally vary between roadway sections within the same functional classification. Consequently, an adjustment was necessary to account for this variation, and it is discussed later in this section.

The hourly capacity estimates were made on a volume per lane basis. The per lane hourly capacities were initially assumed to be: 2000 vehicles per hour (VPH) for interstates; 1600 VPH for freeways, expressways, and other principal rural arterials; 1400 VPH for other principal urban arterials and minor rural arterials; and 1000 VPH for all other classifications. These capacities also will vary between sections of the same functional classification. This variation is caused by such factors as lane widths, signal timings, and turning movements.

The problem of accounting for the variations in peak-hour percentages and per lane capacities between roadway sections was resolved by utilizing an adjusting factor. This factor was calculated from the following equation:

$$K = \frac{IVC}{\frac{PH*IADT}{100*NL*CAP}} \qquad (6.4)$$

where:

K = adjusting factor.

IVC = initial section V/C ratio.

PH = peak-hour percentages (Table 24).

IADT = initial section average daily volume.

NL = number of lanes (one direction) in the section.

CAP = estimated hourly capacity per lane.

The initial V/C ratios, number of lanes, and initial average daily volumes are known from the simulation procedure described earlier. Hence the adjusting factor can be readily calculated.

This adjusting factor is merely a ratio of peak-hour percentage correction to the hourly capacity correction. Once the adjusting factor is known, future volume/capacity ratios can be determined from Equation 6.5.

$$VC = K * \frac{\frac{PH}{100} * AV}{NL * CAP} \tag{6.5}$$

where

VC = volume/capacity ratio in the desired year.

AV = daily volume in the desired year.

All other variables are same as in Equation 6.4.

Items such as the addition of lanes, increased lane width, and assumptions regarding peaking characteristics will affect future V/C ratios and the adjustment factors. The impacts that such items will have on V/C ratio projections are discussed in the next chapter.

Projection of Pavement Conditions - The AASHO Road Test performance equations were used as a basis to estimate future pavement conditions since the results provided by these equations are consistent with pavement life experience in Indiana (3). The AASHO Road performance equations assume the following forms:

$$P = C_0 - (C_0 - C_1) \left(\frac{W}{\rho}\right)^{\beta} \tag{6.6}$$

where

P = the present serviceability rating (PSR)

C_0 = the initial serviceability rating

C_1 = the serviceability rating below which the pavement is considered to be out of service

W = the accumulated axle load applications at the time when P is to be determined.

β and ρ are functions of design and load and are determined from the following equations:

$$\beta = 0.4 + \frac{0.81\ (L_1+L_2)^{3.23}}{(D_1+1)^{5.19}\ L_2^{3.23}} \tag{6.7}$$

$$\rho = \frac{10^{5.93}\ (D_1+1)^{9.35}\ L_2^{4.33}}{(L_1+L_2)^{4.79}} \tag{6.8}$$

For rigid pavements:

$$\beta = 1.0 + \frac{3.63\ (L_1+L_2)^{5.2}}{(D_2+1)^{8.46}\ L_2^{3.52}} \tag{6.9}$$

$$\rho = \frac{10^{5.85}\ (D_2+1)^{7.35}\ L_2^{3.28}}{(L_1+L_2)^{4.62}} \tag{6.10}$$

where

ρ and β = design and load functions.

L_1 = nominal axle weight in kips.

L_2 = 1 for single axle vehicles
2 for tandem axle vehicles

D_1 = thickness index (described earlier)

D_2 = slab thickness, inches

The initial serviceability rating (C_0 in Equation 6.6) is known from the assignments of pavement conditions. The serviceability ratings below which the pavement can be considered to be out of service (C_1 in Equation 6.6) were determined to be 2.0 for principal arterials and 1.5 for minor arterials and collectors using the values presented in the National Highway Functional Classification and Needs Study Manual (34) as a basis.

In Equations 6.7-6.10, the thickness indices and slab thicknesses are already known from the pavement type assigned to a particular section as discussed earlier. Therefore, to calculate ρ and β, it is necessary only to determine the nominal axle weights (L_1) and establish whether these weights are from single or tandem axles (L_2).

The basic approach used to determine L_1 and L_2 was to simulate a representative sample of vehicles and their associated axle weights, and then to translate these axle weights into 18 kip single axle weight equivalents.

Vehicle Axle Weight Sampling - Three categories of vehicles are considered in the axle weight analysis; automobiles, single unit trucks and combination trucks. The axle weight analysis was achieved by simulating a random sample of 1000 vehicles in each of the three categories mentioned above. Details of this sampling procedure are presented in the following paragraphs.

When considering the relative impact on pavement deterioration, the axle weights of automobiles are insignificant when compared with

truck axle weights, however, for the sake of completeness, automobile axle weights were also considered.

The estimation of auto axle weights was made by assuming that auto weights are normally distributed. A mean value of 3,300 pounds and a standard deviation of 800 pounds was chosen on the basis of findings in literature (35). It was assumed that the front axle would carry 60 percent of the total vehicle weight and the rear axle would carry the balance. A minimum value of 1,200 pounds was applied since it was not considered likely that an auto would weigh less than this amount.

Three sub-categories of single unit trucks were considered due to the high variation in loading characteristics. These sub-categories are: 1) 2-axle vehicles with 4 tires, 2) 2-axle vehicles with 6 tires, and 3) vehicles with 3 axles or more. It was assumed that the weights of loaded and empty vehicles in each sub-category would be normally distributed. This assumption was made on the basis of the truck weight distribution summaries presented in the 1975 National Truck Characteristic Report (NTCR) (24). The percentages of loaded and empty vehicles were also determined from this report and the values used were 50.6% and 49.4%, respectively.

Similarly, combination trucks were divided into 3 sub-categories; 3 axle vehicles, 4 axle vehicles, and vehicles with 5 axles or more. Once again the loaded and empty weight distributions within each sub-category were assumed to be normal. The percentages of loaded and empty vehicles were estimated to be 69.8 and 31.2 respectively.

The percent of vehicles in each sub-category, the means, standard deviations, and the fractions of load on each axle, for each sub-category of single unit and combination trucks, are presented in Table 25. This table was derived from the data provided in the 1975 NTCR (24).

The procedure implemented to establish the weight of each truck sample vehicle within each category (single unit or combination) consisted of the following steps: 1) selecting the sub-category by generating uniformly distributed random numbers and using the percent of trucks by truck type as the probability of selection; 2) determining whether the vehicle was loaded or empty by generating uniformly distributed random numbers using the percent of loaded and empty trucks as the probability; 3) estimating the vehicle weight by generating normally distributed random numbers using the appropriate mean and standard deviation. Once the weight of each sample truck is known, the weight is distributed to the axles using the fractions of weights by axle shown in Table 25.

These resultant axle loads (both automobile and trucks) are translated into 18 kip single axle equivalent loads (SAEL) by using Equations 6.11, 6.12 and 6.13 which were derived from the AASHO Road Tests (36).

For single axles:

$$18\ SAEL = 6.213 * 10^{-6} * AL^{4.16} \qquad (6.11)$$

For tandem axles, flexible pavements:

$$18\ SAEL = 4.711 * 10^{-7} * AL^{4.16} \qquad (6.12)$$

TABLE 25. TRUCK WEIGHT MEANS, STANDARD DEVIATIONS, AND PERCENTAGE OF WEIGHTS BY AXLE.

VEHICLE TYPE 1/	PERCENT OF TRUCKS BY TYPE	MEAN WEIGHT (IN KIPS)	STANDARD DEVIATION (IN KIPS)	WEIGHTS BY AXLE 2/ 1	2	3
		EMPTY				
SINGLE UNIT						
2 AX 4 TIRE	77.0	5.5	2.0	.42	.58	-
2 AX 6 TIRE	19.0	10.5	4.0	.44	.56	-
3 AX OR MORE	4.0	17.0	7.0	.38	.62T	-
COMBINATION						
3 AXLE	5.0	22.0	7.0	.31	.37	.32
4 AXLE	15.0	25.0	8.0	.25	.25	.50T
5 AXLE OR MORE	80.0	30.0	4.0	.26	.40T	.34T
		LOADED				
SINGLE UNIT						
2 AX 4 TIRE	77.0	6.2	2.6	.31	.69	-
2 AX 6 TIRE	19.0	14.7	6.0	.37	.63	-
3 AX OR MORE	4.0	34.0	14.0	.28	.72T	-
COMBINATION						
3 AXLE	5.0	30.0	5.0	.27	.40	.33
4 AXLE	15.0	39.0	12.0	.18	.34	.48T
5 AXLE OR MORE	80.0	60.0	14.0	.15	.42T	.43T

T = TANDEM AXLES
1/ TANDEM AXLES COUNTED AS TWO AXLES
2/ TANDEM AXLES COUNTED AS ONE AXLE

For tandem axles, rigid pavements:

$$18\ SAEL = 9.07 * 10^{-7} * AL^{4.12} \qquad (6.13)$$

where

18 SAEL = 18 kip single axle equivalent load.

AL = nominal axle load in kips.

The summation of all of the 18 kip SAEL's within each of the three categories (auto, single unit, and combination trucks) provides the equivalent axle loads per 1000 vehicles by vehicle category. For projective purposes and ultimately estimating accumulated axle load applications (W in Equation 6.6), it is desirable to transform the above results into 18 kip SAEL's per 1000 vehicles, irrespective of vehicle category. This was accomplished by approximating the percentage of vehicle categories operating on each functional classification. These percentages were derived from the 1975 NTCR and are summarized in Table 26. Hence, the number of 18 kip SAEL's per 1000 vehicles operating on each functional classification can be determined simply by multiplying the percentages in Table 26 by the corresponding summation of 18 kip SAEL's derived from each of the three 1000 vehicle samples.

Referring back to Equations 6.7-6.10, ρ and β can be readily calculated for all vehicles, now that L_1 is known to be 18 kips and L_2 is one (since all tandem loads are now single axle equivalents). The only remaining requirement, to project the pavement condition, is the estimation of the number of axle load applications during a specified time period (W in Equation 6.6). In the present analysis,

TABLE 26. 1975 VEHICLE TYPES AS A PERCENT OF ALL VEHICLES (BY FUNCTIONAL CLASSIFICATION).

	AUTOS	SINGLE UNIT TRUCKS	COMBINATION TRUCKS
RURAL:			
INTERSTATE	70.0	14.7	15.3
OTHER PRIN ART	70.0	20.3	9.7
MINOR ARTERIALS	72.0	20.3	7.7
MAJOR COLLECTORS	72.0	23.5	4.5
MINOR COLLECTORS	72.0	23.5	4.5
ALL URBAN:			
INTERSTATE	80.0	11.0	9.0
OTH FWY & EXPWY	80.0	14.0	6.0
OTHER PRIN ART	80.0	16.0	4.0
MINOR ARTERIALS	75.0	23.0	2.0
COLLECTORS	75.0	23.0	2.0

pavement conditions are calculated annually; the number of annual load applications on a given roadway section is determined by the following equation:

$$LA = \frac{ADT}{1000} * 365 * ELPTV \qquad (6.14)$$

where

LA = the number of annual load applications.

ADT = daily traffic volume on the section.

ELPTV = number of 18 kip SAEL's per 1000 vehicles operating on the system.

As the above equation indicates, the number of load applications in any given year will be a function of the daily volume (the projection of which was described earlier) and the 18 kip equivalent loads per 1000 vehicles. The future values of ELPTV will be influenced by: 1) shifts in the percent of vehicle type using each functional classification, 2) changes in the weight distributions of trucks and autos, and 3) fluctuations in the percentage of loaded trucks. The sampling technique devised for the present analysis allows an evaluation of the impacts of changing weight distributions and variations in the percentage of loaded trucks. However, it can be assumed, on the basis of recent trends, that the above two factors will be essentially constant over the time period of this analysis provided that the maximum axle weight laws are not revised.

Shifts in the percent of vehicle types using each functional classification were determined by asserting that the increase in the 18 kip ELPTV's would be proportional to the increase in commercial

truck VMT relative to the increase in total VMT. This technique is valid since an overwhelming percentage of the total 18 kip ELPTV is determined by commercial vehicles. Therefore, future 18 kip ELPTV's are estimated on each functional classification by applying the following equation:

$$ELPTV = \frac{1 + \frac{PICV}{100}}{1 + \frac{PITV}{100}} * ELPTV_{-1} \qquad (6.15)$$

where

ELPTV = 18 kip equivalent axle loads per 1000 vehicles in desired year.

PICV = percent increase in commercial VMT from the preceding year.

PITV = percent increase in total VMT from the preceding year.

$ELPTV_{-1}$ = ELPTV in preceding year.

Once the ELPTV is known, the number of annual load applications may be calculated using Equation 6.14 and the summation of these annual load applications is used in Equation 6.6 (as W) from which the pavement condition can be determined annually.

The only remaining factor affecting future pavement conditions is the possible repair or resurfacing of a roadway section, and this item is discussed in the next chapter.

Computation of Condition Index Values

Once the pavement type, pavement condition, peak-hour volume/capacity (V/C) ratios, and lane width of each section are known; the appropriate condition indices can be readily calculated. This calculation is performed by using the following set of equations:

For pavement type;

$$CI_1 = ((D - 1.6) * CW_1)/8.4 \quad (6.16)$$

where

CI_1 = the portion of the condition index determined by pavement type.

D = the slab thickness for rigid pavements or the thickness index for flexible pavements.

CW_1 = the condition index weight for pavement type (Table 19).

Pavements with a "D" of 10 inches or more are given total points (i.e. $CI_1 = CW_1$) and those pavements with a "D" of 1.6 inches or less are given no points ($CI_1 = 0$).

For pavement condition;

$$CI_2 = ((PC - 1.) * CW_2)/4 \quad (6.17)$$

where

CI_2 = the portion of the condition index determined by pavement condition.

PC = the present serviceability rating (PSR) of the pavement 0 to 5).

CW_2 = the condition index weight for pavement condition (see Table 19).

Sections with a PSR of one or less are given no points ($CI_2 = 0$).

For peak-hour V/C ratios;

$$CI_3 = ((1. - PVC) * CW_3)/.6 \quad (6.18)$$

where

CI_3 = the portion of the condition index determined by the peak-hour V/C ratios.

PVC = the peak-hour V/C ratio of the section.

CW_3 = the condition index weight for V/C ratios (see Table 19).

Volume/capacity ratios of 0.4 or less are given total points ($CI_3 = CW_3$).

For lane widths;

$$CI_4 = ((LW - 9.) * CW_4)/3 \qquad (6.19)$$

where

CI_4 = the portion of the condition index determined by the lane widths.

LW = the lane widths of the section in feet.

CW_4 = the condition index weight for lane widths (Table 19).

Sections with a lane width of 12 feet or more are given total points ($CI_4 = CW_4$) and those with lane width of 9 feet or less are given no points ($CI_4 = 0$).

The condition index of any roadway section can then be determined simply by adding the results of Equations 6.16 to 6.19.

In the present study, the condition index of any given functional classification is equal to the average of the classification's individual section condition indices weighted by the corresponding section traffic volumes. This is illustrated by the following equation:

$$SCI = \frac{\sum_{i=1}^{n} (CI_i * V_i)}{\sum_{i=1}^{n} V_i} \qquad (6.20)$$

where

SCI = total functional classification system condition index.

CI_i = the condition index of section i.

V_i = the traffic volume of section i.

n = the total number of sections comprising the specified functional classification.

The condition indices determined in this chapter are used as 1) a measurement of highway performance and 2) a basis to distribute the funds available for highway repair among the roadway sections comprising each functional classification. The details of the technique utilized to distribute funds to roadway sections are discussed in the next chapter.

CHAPTER 7

ALLOCATION OF CAPITAL FUNDS

The allocation of capital funds was performed in two steps. First, capital funds were distributed to individual highway functional classifications, and second, the capital funds distributed to such functional classifications were allocated to specific roadway sections within each functional classification. The former step will be discussed in the next chapter and the present chapter is concerned only with the allocation of funds to roadway sections.

Allocation of Capital Funds to Roadway Sections

Since it is highly improbable that sufficient capital improvement funds will be available to repair all deficiencies on every roadway section; it is necessary to apply a priority setting technique whereby the available funds can be allocated to those sections with the most critical deficiencies. The method used in the present study establishes funding priority on the basis of two equally weighted factors. The first factor gives priority to the roadway sections with low condition indices. The second factor gives priority to roadway sections with the most cost-effective improvement. Thus the procedure is to allocate half of the funds on the basis of condition indices and the remainder on the basis of cost-effectiveness factors.

The determination of the first factor is simple, since the condition indices of each roadway section are known from the procedures discussed in the previous chapter. The cost-effectiveness of an improvement, which is used as a basis for the application of the second priority factor, is defined by the following equation:

$$CE_i = \frac{(CI_N - CI_I) * V}{Cost_i} \qquad (7.1)$$

where

CE_i = the cost-effectiveness of improvement type i in a specified year for a given section

CI_N = the condition index after the implementation of improvement type i.

CI_I = the initial condition index of the roadway section in the specified year

V = the traffic volume on the roadway section in the specified year

$Cost_i$ = the cost of implementing improvement type i in the specified year on the given section.

The traffic volume (V) and the Initial Condition Index (CI_I) are known in any given year from the procedures discussed in the preceding chapter. It is therefore necessary to establish; 1) the types of needed improvements, 2) the effects that such improvements will have on section condition indices and 3) the costs of such improvements in any given year.

Improvement Types

In this analysis, as is the case with most major studies in this subject area (3,5,6,32), capital improvements are categorized into eight major improvement types. These categories, along with their definitions are as follows:

1. New location - complete construction of the roadway on a new alignment.
2. Reconstruction - reconstruction of the roadway on essentially the same alignment.
3. Isolated reconstruction - reconstruction of some portion of the roadway to correct a particular deficiency such as a dangerous curve.
4. Major widening - addition of lanes to the roadway section.
5. Minor widening - provides for additional lane width.
6. Resurfacing - overlaying of the existing pavement.
7. Resurfacing and shoulder improvements - in addition to the overlaying of existing pavements, provisions for the widening of shoulders are made.
8. Structures - the rehabilitation or replacement of deficient structures.

Data limitations necessitated the allocation of a constant percentage of capital funds to structure improvements, and hence, such improvements are excluded from further discussion in this chapter.

The type of improvement needed on a specific roadway section was determined by applying data available in the 1972 National Highway Needs Report (32) in which national estimates of needed capital

improvements (presented in Tables IV-5, IV-15, and IV-16) from 1970 to 1990 by improvement type and functional classification are provided. These estimates were applied to Indiana and used to establish the relative probability of a specific capital improvement type being assigned to any given roadway section within each functional classification.

Effects of Improvements on the Condition Index

After the assignment of the improvement type to each roadway section is made through a random sampling technique the condition index of the section resulting from the improvement (CI_N in Equation 7.1) can be determined. This determination is made by evaluating the effects that each improvement type will have on the four basic components of the condition index. These effects are outlined below.

1. Pavement Type - All improvement types may potentially change this component. The pavement type is appropriately re-determined on the basis of the current truck volume (and its estimated growth rate) using the technique for pavement thickness estimation described in the preceding chapter.
2. Pavement Condition - Once again, all improvement types will affect this component. The present serviceability rating (PSR) is assigned maximum value, which was estimated to be 4.8 for principal arterials and 4.4 for all other classifications, and the accumulated axle loads are re-initialized.

3. Peak-Hour Volume/Capacity Ratios - Only lane widths and lane additions were considered to affect V/C ratios. Therefore the major widening, minor widening, new location, and reconstruction improvements were considered to affect this component. The V/C ratios are recalculated by estimating the increased capacity resulting from the addition of lanes and/or increases in lane widths. The 1965 Highway Capacity Manual (30) was used as a basis for such calculations.
4. Lane Widths - Major widening, minor widening, new location and reconstruction will affect this component. It is assumed that the lane widths will be raised to the current design standard of 12 feet when any of the above improvement types are implemented.

After the values of the condition index components are determined, after the implementation of a specified improvement type, the CI_N value in Equation 7.1 can be readily calculated.

Improvement Costs

The costs associated with each capital improvement type ($Cost_i$ in Equation 7.1) were estimated by developing an average cost per mile using the national data provided in the 1972 National Highway Needs Report and applying these values to Indiana. The resultant costs (1969 prices) are presented in Table 27. To evaluate the impact that economic conditions will have on these costs, annual projections were made by; 1) transforming the 1969 unit costs to 1975 unit costs using the cost indices provided in the 1975 Highway Statistics (1) and 2) using the deflators for capital improvement presented in Figure 16.

TABLE 27. 1969 ESTIMATIONS OF COSTS PER MILE BY CAPITAL IMPROVEMENT TYPE (IN THOUSANDS OF 1969 DOLLARS).

FUNCTIONAL CLASSIFICATION	NEW LOCATION	RECONST.	ISOLATED RECONST.	MAJOR WIDENING	MINOR WIDENING	RESURF. & SHLDR. IMP.	RESURF.
RURAL:							
INTERSTATE	363	1722	126	631	326	173	98
OTHER PRIN ART	1042	607	153	581	177	128	67
MINOR ARTERIAL	664	358	91	565	145	86	41
MAJOR COLLECTOR	283	231	54	584	120	51	22
MINOR COLLECTOR	161	145	35	185	89	40	18
URBAN:							
INTERSTATE	8244	3929	5311	2021	1233	658	223
OTH FWY & EXPWY	5385	3864	758	2826	1305	574	207
OTHER PRIN ART	2387	1452	414	1481	740	225	139
MINOR ARTERIALS	1095	942	231	1004	502	128	116
COLLECTORS	632	587	123	705	350	115	68
SMALL URBAN:							
INTERSTATE	-	-	-	764	800	273	155
OTH FWY & EXPWY	2442	2016	1087	921	877	403	172
OTHER PRIN ART	1575	987	249	905	605	149	86
MINOR ARTERIALS	795	598	196	619	419	138	66
COLLECTORS	582	472	721	506	306	107	49

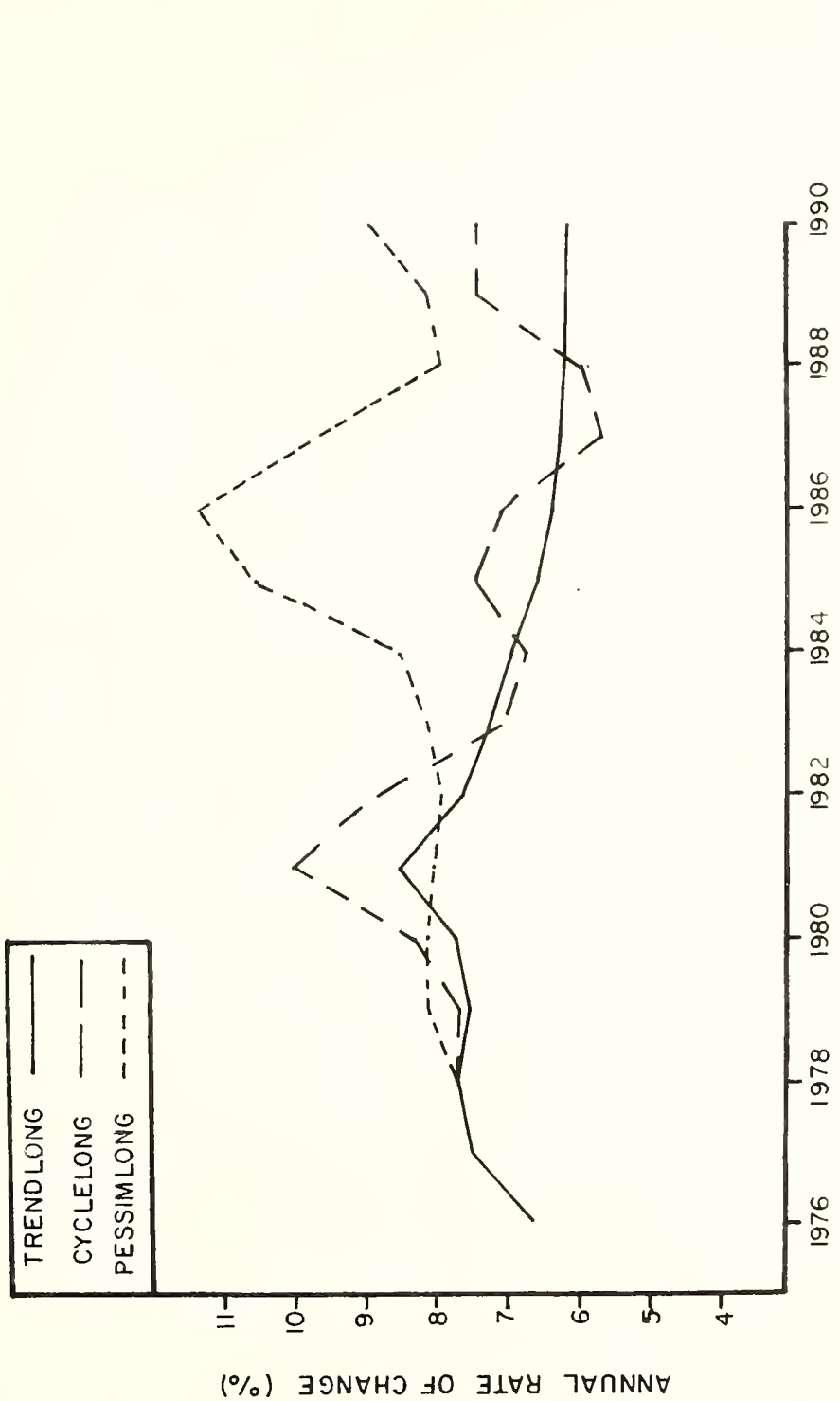

FIGURE 16. SUMMARY OF DRI DEFLATORS FOR HIGHWAY CAPITAL IMPROVEMENTS

SOURCE: REFERENCE 7.

Equation 7.1 can now be applied to determine the cost effectiveness of a capital expenditure on each roadway section. Subsequently, the priority of expenditures can now be established.

Improvement Assignment

The approach described thus far is similar to that used by the 1976 National Highway Inventory and Performance Study, however unlike the 1976 NHIPS, which utilized a deterministic approach in priority setting, the present study's approach is probabilistic. Two major arguments can be raised against the application of a purely deterministic approach to set priorities for capital expenditures. First, since the condition index requires a considerable amount of subjective input, it is ill-advised to use it as an absolute basis. The second argument relates to the impact of political decisions which tend to make the programming process highly probabilistic.

As a result of the deficiencies inherent in the deterministic approach in priority programming, a dual threshold analysis technique (which is probabilistic by nature) was developed for use in this study. This technique assumes that all roadway sections with a condition index below a specified threshold or a cost effectiveness value above a specified threshold have an equal probability of selection. The thresholds used in this study are simply the average condition index and the average cost-effectiveness factor of the roadway sections which comprise each functional classification. Therefore, the priority setting of capital improvements was achieved by the application of the following steps:

1. Roadway sections are selected randomly and compared to the average condition index of the functional classification.
2. When a roadway section is found to have a condition index less than the average, the section is assigned the appropriate improvement and both the condition index and cost effectiveness factor are revised to reflect the impact of that improvement. The cost of the improvement is calculated by multiplying the section lengths with the costs per mile derived from the values presented in Table 27.
3. Roadway sections are selected randomly and compared to the average cost effectiveness factor of the roadway sections comprising a particular functional classification.
4. When a roadway section is found to have a cost effectiveness factor above the average, the same procedure described in step 2 is implemented.
5. Steps 1 through 4 are repeated until the total capital improvement funds allocated to the specific functional classification during a particular year are exhausted.

This dual threshold analysis technique provides projections of condition indices by functional classification which are only slightly affected by the order in which individual roadway sections are selected for threshold comparisons. It is felt that the consistency of condition index projections as well as the theoretical basis of this approach makes the dual threshold analysis technique an appropriate procedure instead of the deterministic approaches used in the past.

Stopgap Repairs

In addition to capital improvements, provisions were made for stopgap repairs. Stopgap repairs are defined as those repairs necessary to keep a roadway section in usable condition. These repairs, which include such activities as isolated resurfacing, were made only when insufficient funding is available to perform the needed capital improvement.

In this study, stopgap repairs were considered only on roadway sections with severely deteriorated pavements. The cost of such repairs is assumed to be 15% of the resurfacing costs (3). These repairs were assumed to add, in general, three to five years of service life to the roadway section.

CHAPTER 8

MODEL RESULTS

A listing of the computer model that eventually evolved is presented in Appendix A. Before the model could be applied it was necessary to establish the validity of the model results. The 1975 highway performance data, which was used as the basis for the estimation of highway performance in this study, was the only complete performance data available, and therefore, it was not possible to validate the model by comparing model results with more recent data. Subsequently, the model was validated by 1) carefully monitoring the values of model variables at various stages of the computational process in terms of their consistency, and 2) comparing the model results for 1990 with those obtained by the 1976 National Highway Inventory and Performance Study which is the only other study to provide detailed projections of future highway performance. The results of the present study were found to be compatible with those obtained in the 1976 NHIPS, although a direct comparison was not possible since the 1976 study provides highway performance on a national basis, while the present study projects highway performance for the state of Indiana.

Model Application

A number of scenarios was considered to analyze the effects that legislative policy options, changes in future travel characteristics and a relaxation of present improvement standards may have on the performance of the Indiana highway system. In discussing the results in this chapter, the scenarios tested are identified by a letter and number coding system. The letter denotes the macroeconomic model used to provide economic data for the scenario run. For example, T indicates that the TRENDLONG data was used, C the CYCLELONG data, and P the PESSIMLONG data. The number which follows the letter in the scenario coding system refers to a specific option of possible legislative alternatives along with other attendant assumptions.

It was assumed, in all scenarios tested, that legislative policy options would have no effect on the macroeconomic data used as input. The only exception to the assumption was the gasoline price deflator which would be influenced by changes in fuel taxing rates. This assumption is reasonable since a recent study observed that a probable range of highway funding options have negligible impacts on economic conditions (5).

Revenue Assumptions

Revenues from federal agencies, state general fund appropriations, and other non-state road-user tax sources, were estimated by assuming that such revenues would be proportional to the revenues collected from state road-user taxes. This assumption was based on 1) an analysis of past data, which revealed that revenues from non-state

road-user sources have historically constituted a relatively constant share of total highway revenues (see Figure 17) and 2) consideration of the taxing effort, which is a measure of a state's taxing policies relative to other states, and is an important factor in determining the amount of federal aid allocated to states, and therefore, revenues from federal sources can be expected to be proportional to changes in state road-user tax revenues (37).

Disbursement Assumptions

In this study, highway disbursements are categorized into four broad classifications: 1) local capital outlays which include all expenditures for capital improvements on the local road functional classification, 2) non-local capital outlays which include all expenditures for capital improvements on non-local functional classifications (e.g. interstates, arterials, and collectors), 3) structure costs which include funds allocated for the rehabilitation of roadway structures, and 4) routine maintenance, administration, and all others. It was assumed that the last group of expenditures would increase at an annual rate that is proportional to the annual increase in the price deflator for capital outlays. Hence the disbursements for this group were determined from the following equation:

$$DMA = DMA_{-1} * (1. + DCO * PR) \qquad (8.1)$$

where

DMA = the annual disbursement for maintenance, administration, and all others.

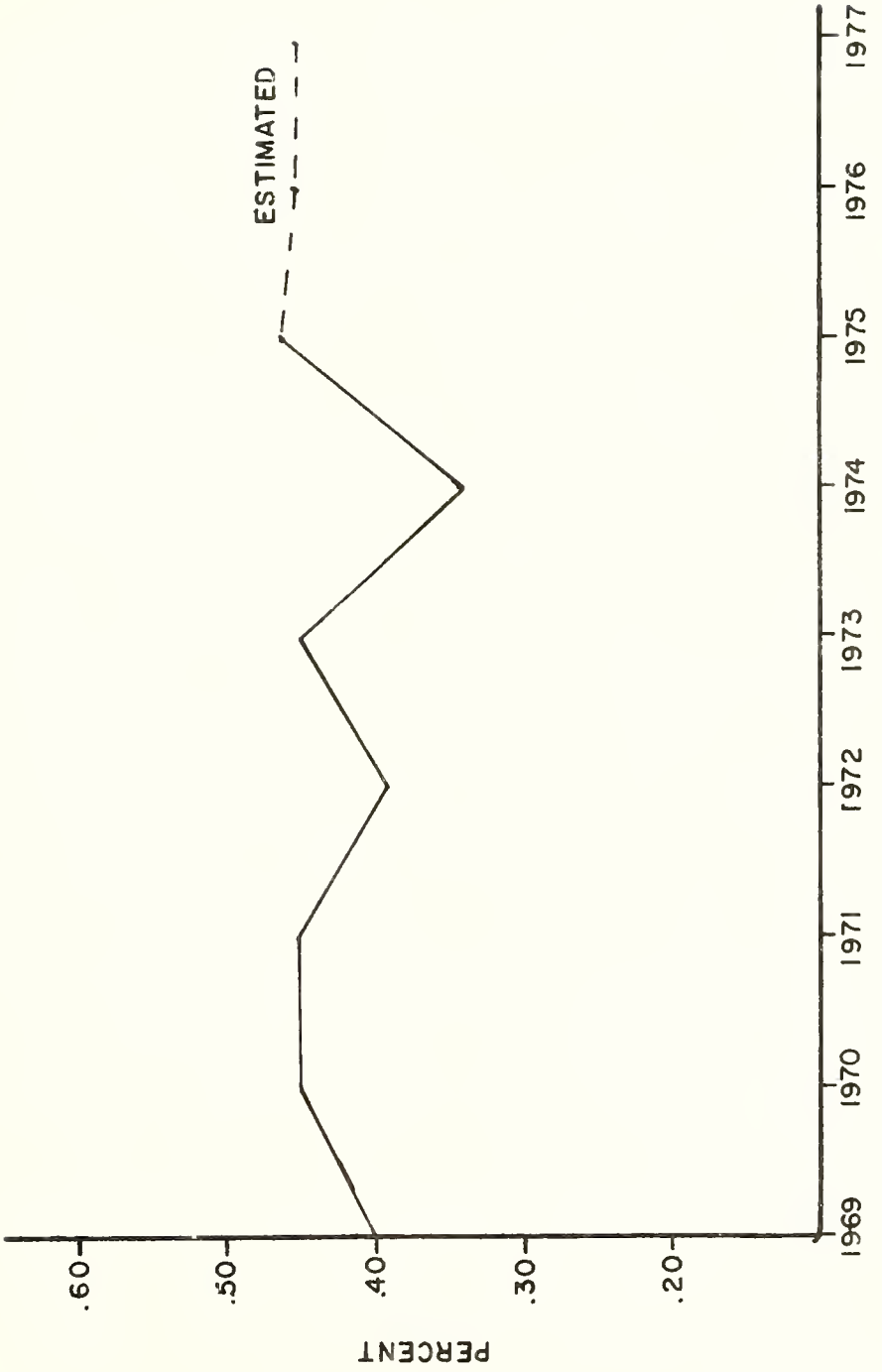

FIGURE 17. PERCENT OF TOTAL HIGHWAY RECEIPTS FROM SOURCES OTHER THAN STATE ROAD-USER TAXES FOR INDIANA

SOURCE: REFERENCE 1.

DMA_{-1} = the disbursement for maintenance, and so on in the preceding year,

DCO = the price deflator for capital outlays,

PR = the assumed proportion of DMA increase relative to DCO increase.

The above equation is based on an analysis of recent trends which revealed an approximate equality between maintenance and operation cost increases and increases in capital outlay costs (1). The proportion (PR in Equation 8.1) was introduced to reflect the ability of the highway agencies to reduce low priority routine maintenance and administration programs, thereby permitting more funds to be directed to needed capital improvement projects. A value of .25 was used in all scenarios for this proportion. This value reflects a considerable effort by the agencies to limit such disbursements, and this value is consistent with recent Indiana highway disbursement trends (1).

Once the disbursements for maintenance, administration, and others have been calculated, a fixed percentage of the remaining funds is allocated to structures, local and non-local capital outlays. It was assumed for all scenarios that 33 percent of the funds would be allocated to local road capital improvement projects, 3 percent of the funds would be allocated to structures, and the remaining 64 percent to non-local capital improvements. These values were estimated using historical data and the values estimated by previous studies (3,5,32).

Distribution of Non-Local Capital Funds Among Functional Classifications

Two alternate funding distributions were developed using, as a basis, the funding distributions presented in the 1976 National Highway Inventory and Performance Study (5) and the estimation of future Indiana capital improvement needs made for the 1972 National Highway Needs Study (32). The first funding distribution (series I) was used for all scenarios which assume that the highway performance standards and the travel characteristics would remain unchanged over the time period of the present study. The series I distribution allocates a relatively large percentage of capital improvement funds to high volume facilities (see Table 28). This distribution reflects state preference for maintaining the condition of high volume facilities as opposed to low volume facilities which are given a lower priority particularly when funding levels are not sufficient to meet highway needs.

The second funding distribution (series II) was used for scenarios that assumed changes in highway performance standards or in travel characteristics. These assumed changes result in a considerable reduction in the need for capital improvements on high volume facilities. Subsequently, the series II distribution (see Table 29) allocates more funding to low volume facilities than does the series I distribution.

Discussion of Options

Table 30 summarizes the assumptions made for the seven options used in this analysis. Appendix B presents a sample computer output

TABLE 28. SERIES I PERCENT OF TOTAL CAPITAL IMPROVEMENT FUNDS ALLOTTED TO EACH FUNCTIONAL CLASSIFICATION.

SYSTEM	DISTRIBUTION OF FUNDS (PERCENT)
RURAL:	
INTERSTATE	8.0
OTHER PRIN ART	9.5
MINOR ARTERIALS	16.5
MAJOR COLLECTORS	6.0
MINOR COLLECTORS	6.0
URBAN:	
INTERSTATE	18.0
OTH FWY & EXPWY	7.0
OTHER PRIN ART	12.0
MINOR ARTERIALS	5.5
COLLECTORS	3.0
SMALL URBAN:	
INTERSTATE	0.5
OTH FWY & EXPWY	1.0
OTHER PRIN ART	3.0
MINOR ARTERIALS	2.0
COLLECTORS	2.0

TABLE 29. SERIES II REVISED PERCENT OF TOTAL CAPITAL IMPROVEMENT FUNDS ALLOTTED TO EACH FUNCTIONAL CLASSIFICATION.

SYSTEM	DISTRIBUTION OF FUNDS (PERCENT)
RURAL:	
INTERSTATE	5.5
OTHER PRIN ART	6.0
MINOR ARTERIALS	14.0
MAJOR COLLECTORS	10.0
MINOR COLLECTORS	10.5
URBAN:	
INTERSTATE	12.5
OTH FWY & EXPWY	8.0
OTHER PRIN ART	11.0
MINOR ARTERIALS	8.5
COLLECTORS	3.5
SMALL URBAN:	
INTERSTATE	0.1
OTH FWY & EXPWY	0.5
OTHER PRIN ART	1.9
MINOR ARTERIALS	3.0
COLLECTORS	3.0

TABLE 30. SUMMARY OF OPTION ASSUMPTIONS.

	OPTION						
	1	2	3	4	5	6	7
STATE ROAD-USER TAX RATES	SAME AS 1979	$.11 GAS TAX	$.11 GAS TAX	20 PERCENT AD VALOREM TAX	SAME AS 1979	$.11 GAS TAX	$.11 GAS TAX
FRACTION OF TOTAL REVENUES OBTAINED FROM NON-STATE ROAD-USER TAX SOURCES	.45	.45	.55	.45	.45	.45	.45
DISTRIBUTION OF CAPITAL FUNDS TO FUNCTIONAL CLASSIFICATIONS	SERIES 1	SERIES 1	SERIES 1	SERIES 1	SERIES 1	SERIES 2	SERIES 2
OTHER ASSUMPTIONS	NONE	NONE	NONE	NONE	INCREASE IN PERMISSIBLE AXLE LOADS.	RELAXED IMPROVEMENT STANDARDS.	REDUCE PEAKING BY 20 PERCENT.

of a typical option model run. The results of all seven options tested are discussed in the following paragraphs.

Option 1

This option was designed to analyze the effects that a continuation of present Indiana highway taxing policies will have on future Indiana highway performance. It was examined in terms of all three macroeconomic forecasts so that the full impacts of varying national economic conditions could be assessed. Table 31 summarizes the 1990 values of select model parameters using the TRENDLONG, CYCLELONG, and PESSIMLONG macroeconomic forecasts. As might be expected, when comparing the three model run parameters presented in this table, the high inflation rates and lower industrial productions of the CYCLELONG and PESSIMLONG model runs result in lower VMT values, lower fleet fuel efficiencies, higher gasoline prices, and lower highway revenues which have less buying power per dollar.

The effects that economic conditions have on highway performance are shown in Table 32. This table summarizes the percent change in the condition indices of each functional classification between 1976 and 1990 under Option 1. It is apparent that if current highway taxing policies are continued, a considerable deterioration is expected in Indiana highway performance, particularly on lower volume facilities. This loss in highway performance arises from an overall decline in system pavement conditions and increased congestion.

As for the impacts of economic conditions, in this option the more pessimistic economic assumptions result in less highway performance

TABLE 31. SUMMARY OF THE 1990 VALUES OF SELECT MODEL PARAMETERS UNDER SCENARIOS T-1, C-1, P-1.

PARAMETER	SCENARIO T-1	SCENARIO C-1	SCENARIO P-1
TOTAL VMT (MILLIONS)	53399	51594	49920
COMBINATION VMT (MILLIONS)	3115	2873	2917
TOTAL FLEET EFFICIENCY (MPG)	18.56	18.51	18.45
RETAIL GAS PRICE (DOLLARS)	1.31	1.48	1.65
TOTAL REVENUES (THOUSANDS OF DOLLARS)	586272	570112	560827
NON-LOCAL CAPITAL OUTLAYS (THOUSANDS OF DOLLARS)	182056	167843	153113
PRICE DEFLATOR FOR CAPITAL OUTLAYS (1975=1.00)	2.75	2.92	3.38
OTHER NON-CAPITAL DISBURSEMENTS (THOUSANDS OF DOLLARS)	314546	319599	332299

TABLE 32. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-1, C-1, AND P-1.

FUNCTIONAL CLASSIFICATION	SCENARIO T-1	SCENARIO C-1	SCENARIO P-1
RURAL:			
INTERSTATE	-11.2	-9.8	-8.9
OTHER PRINCIPAL ARTERIALS	-5.8	-4.1	-3.6
MINOR ARTERIALS	-9.6	-7.6	-7.4
MAJOR COLLECTORS	-22.5	-19.3	-18.7
MINOR COLLECTORS	-29.6	-25.6	-25.4
URBAN:			
INTERSTATE	-13.5	-12.5	-12.1
OTHER FREEWAYS AND EXPRESSWAYS	-14.4	-13.2	-10.9
OTHER PRINCIPAL ARTERIALS	-10.4	-10.3	-9.6
MINOR ARTERIALS	-19.3	-19.1	-17.9
COLLECTORS	-18.5	-18.5	-16.4

loss. This is due to the fact that pessimistic economic assumptions result in 1) less congestion as total VMT growth rates are restrained, and 2) less axle load accumulations as the growth in intercity ton-mileage takes place only on a moderate level. For this option, the above two factors offset the effects of decreasing highway revenues and reductions in per dollar buying power. The result is that a less reduction in highway performance is observed.

It must be pointed out, however, that in no way can it be concluded that more pessimistic economic assumptions will necessarily result in less deterioration in highway performance. In some cases, as will be shown later, revised highway performance standards and travel characteristics result, on certain functional classifications, in less reduction in highway performance, even under more optimistic economic scenarios. This is due to the fact that highway performance is the result of the interaction of economic conditions, the performance criteria used, the travel characteristics assumed, and the physical attributes of each functional classification.

Option 2

Option 2 has essentially the same assumptions as Option 1, however this option implements an 11 cents per gallon gasoline tax in 1980 which is a 3 cent increase over current gasoline tax rates. The increase in gasoline tax, which is also accompanied by increases in funds from other non-state road-user revenue sources, results in a 27 percent increase in total highway revenues in calendar year 1980 (see Table 34) using the TRENDLONG macroeconomic data. The impact

that the additional revenue has on the Indiana highway performance is summarized in Table 33. When comparing scenarios T-1 and T-2 it is evident that the increased revenue results in only moderate improvement in highway performance after a certain threshold level. This is due to the fact that the capital investment/performance curve for each functional classification is asymtotic (see Figure 18), and therefore, a large increase in capital investment may result in only modest increases in the condition index.

Option 3

Option 3 assumes a 3 cents per gallon increase in the gas tax in 1980 accompanied by an increase in the proportion of federal aid, general fund appropriations, and other revenue shares such that these revenue sources constitute 55 percent of the total highway budget as opposed to the 45 percent used in previous options. The above assumptions result in total 1980 highway revenues which are 22 percent and 36 percent greater than the Option 2 and Option 1 1980 revenues respectively, using the TRENDLONG macroeconomic data (see Table 34). Table 33 summarizes the changes in highway performance under scenarios T-1, T-2, and T-3. Once again, the additional revenue results in only moderate reductions in highway performance loss.

Option 4

Option 4 assumes that a 20 percent per gallon ad valorem gasoline tax is implemented in 1980 in an attempt to keep pace with the inflationary pressures which push capital improvement costs up by 275 percent, between 1975 and 1990, under the TRENDLONG macroeconomic

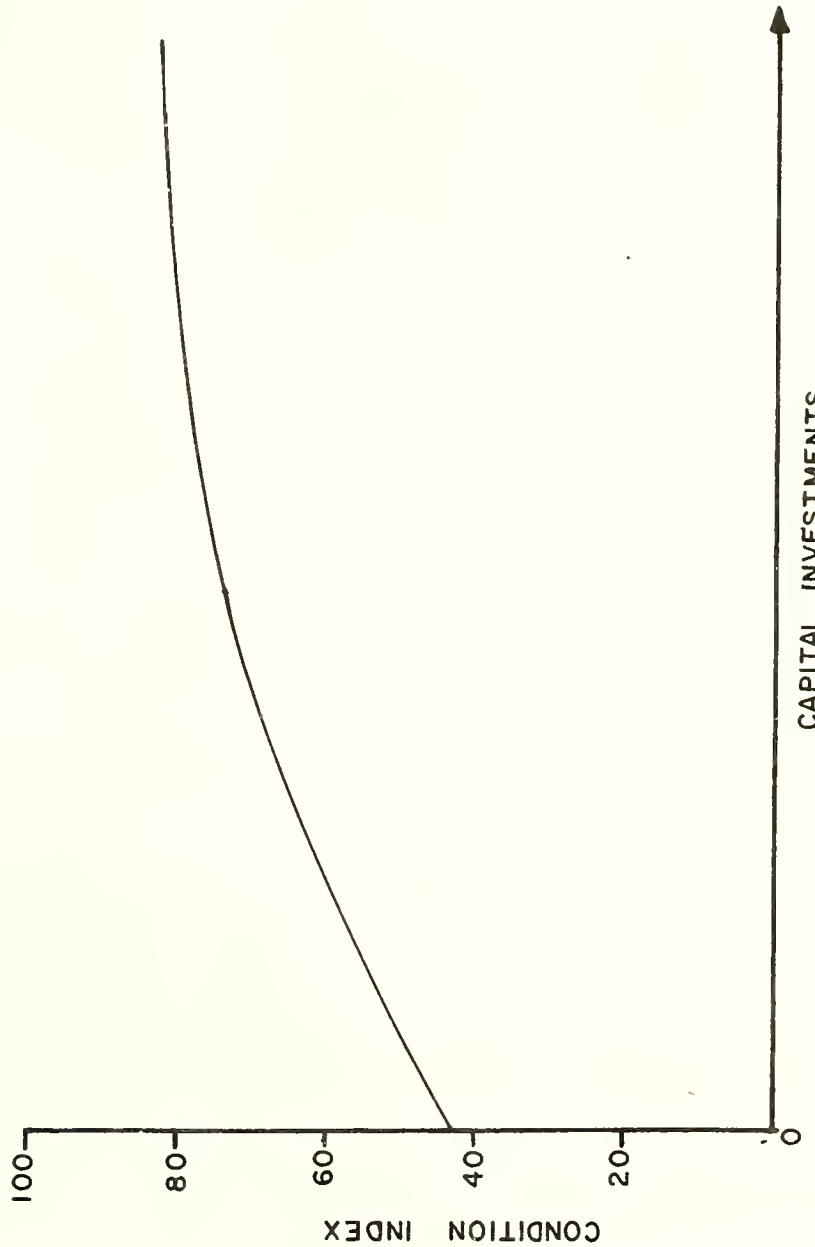

FIGURE 18. GENERALIZED SHAPE OF THE HIGHWAY INVESTMENT / PERFORMANCE CURVE (ONE FOR EACH FUNCTIONAL CLASSIFICATION)

SOURCE: REFERENCE 5.

TABLE 33. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-1, T-2, AND T-3.

FUNCTIONAL CLASSIFICATION	SCENARIO T-1	SCENARIO T-2	SCENARIO T-3
RURAL:			
INTERSTATE	-11.2	-10.0	-7.7
OTHER PRINCIPAL ARTERIALS	-5.8	-3.1	-0.8
MINOR ARTERIALS	-9.6	-5.8	-4.4
MAJOR COLLECTORS	-22.5	-18.6	-12.6
MINOR COLLECTORS	-29.6	-27.0	-23.8
URBAN:			
INTERSTATE	-13.5	-10.7	-7.3
OTHER FREEWAYS AND EXPRESSWAYS	-14.4	-12.5	-10.1
OTHER PRINCIPAL ARTERIALS	-10.4	-9.7	-7.5
MINOR ARTERIALS	-19.3	-18.8	-16.5
COLLECTORS	-18.5	-15.6	-13.7

assumptions. Table 34 summarizes total highway revenues generated by the four options discussed thus far. The ad valorem tax obviously generates the most revenue. This is particularly evident in the mid-1980's when decreasing fuel consumption actually reduces the total revenues collected from the other three options.

Although the highway performance in scenario T-4 is noticeably improved over scenario T-1 (see Table 36), it is evident that, despite a considerable increase in revenues, the highway performance still declines on most functional classifications. This indicates that the generated revenue is still not sufficient to perform the capital improvements necessary to maintain 1975 highway performance. There are essentially two reasons for this. First, the asymtotic shape of the investment/performance curve provides less improvement than would be expected if a linear relationship existed. Second, the ad valorem tax is indexed to the price of fuel, which in the TRENDLONG macro-economic forecast, increases at a rate which is less than the rate of increase in the cost for capital improvements, and therefore, inflation continues to erode highway dollars but to a lesser extent than previous options.

Option 5

Option 5 was designed to evaluate the impacts that an increase in the permissible axle loads would have on Indiana highway performance. Currently Indiana weight limits are 18 kips for single axles, 32 kips for tandem axles, and 73.28 kips for total gross weight. There has been considerable pressure on the Indiana state legislature to raise

TABLE 34. SUMMARY OF TOTAL HIGHWAY REVENUES GENERATED BY SCENARIOS T-1, T-2, T-3, AND T-4 (IN THOUSANDS OF DOLLARS).

	SCENARIO			
YEAR	T-1	T-2	T-3	T-4
1976	587716	587716	587716	587716
1977	593720	593720	593720	593720
1978	597849	597849	597849	597849
1979	598809	598809	598809	598809
1980	598065	761765	930108	884334
1981	596759	758872	926507	921084
1982	593267	753158	919515	957142
1983	590975	748962	914378	991797
1984	587528	743186	907310	1037210
1985	583165	736284	898908	1082107
1986	580312	731508	893022	1128559
1987	579679	729465	890520	1181416
1988	580814	730018	891190	1242025
1989	583106	732149	893790	1309155
1990	586272	735529	897942	1380767

these limits to conform with the weight limits of most other states which are; 20 kips, 32 kips, and 80 kips for single axle, tandem axle, and gross weight respectively. This option implements these higher weight limits at the beginning of 1980. The other assumptions are the same as in Option 1.

The increase in permissible weight limits will have the following impacts on Indiana truck characteristics:

1. The average weight of a loaded truck will increase.
2. The average weight of an empty truck will increase as additional structural support will be required to carry the increase in loads.
3. The commercial VMT will decrease as less truck trips are required to transport the same amount of tonnage.

Estimations of the increases in the mean weights of empty and loaded trucks (see Table 35) were developed from the 1975 National Truck Characteristic Report and other appropriate studies (24,38,39). The standard deviations, weight distributions by axle, and percent of trucks by type, were assumed to be unchanged as the data available to estimate these changes was inconclusive; however, since the increase in the permissible weight limits is relatively small, such an assumption will not cause any significant errors.

The measurement of the decrease in commercial VMT is achieved by estimating the average load carried index (ALCI) described earlier in Chapter 4. The factor was estimated by applying the following equation:

TABLE 35. REVISED TRUCK WEIGHT MEANS, STANDARD DEVIATIONS, AND PERCENTAGE OF WEIGHTS BY AXLE.

VEHICLE TYPE 1/	PERCENT OF TRUCKS BY TYPE	MEAN WEIGHT (IN KIPS)	STANDARD DEVIATION (IN KIPS)	WEIGHTS BY AXLE 2/ 1	2	3
		EMPTY				
SINGLE UNIT						
2 AX 4 TIRE	77.0	5.5	2.0	.42	.58	-
2 AX 6 TIRE	19.0	10.9	4.0	.44	.56	-
3 AX OR MORE	4.0	17.5	7.0	.38	.62T	-
COMBINATION						
3 AXLE	5.0	23.0	7.0	.31	.37	.32
4 AXLE	15.0	27.0	8.0	.25	.25	.50T
5 AXLE OR MORE	80.0	31.2	4.0	.26	.40T	.34T
		LOADED				
SINGLE UNIT						
2 AX 4 TIRE	77.0	7.0	2.6	.31	.69	-
2 AX 6 TIRE	19.0	16.4	6.0	.37	.63	-
3 AX OR MORE	4.0	36.5	14.0	.28	.72T	-
COMBINATION						
3 AXLE	5.0	34.5	5.0	.27	.40	.33
4 AXLE	15.0	43.0	12.0	.18	.34	.48T
5 AXLE OR MORE	80.0	63.0	14.0	.15	.42T	.43T

T = TANDEM AXLES
1/ TANDEM AXLES COUNTED AS TWO AXLES
2/ TANDEM AXLES COUNTED AS ONE AXLE

$$ALCI = \frac{\sum_{i=1}^{6} PT_i * (NMLW_i - NMEW_i)}{\sum_{i=1}^{6} PT_i * (IMLW_i - IMEW_i)} \qquad (8.2)$$

where

ALCI = the average load carried index.

i = the truck type (single unit 2 axle 4 tire, and so on).

PT_i = truck type i as a percent of all truck types.

$NMLW_i$ = new mean loaded weight of truck type i.

$NMEW_i$ = new mean empty weight of truck type i.

$IMLW_i$ = 1975 mean loaded weight of truck type i.

$IMEW_i$ = 1975 mean empty weight of truck type i.

A value of 1.09 was calculated from the above equation indicating a 9 percent average increase in load carried per vehicle. This value was then used in equation 4.2 to calculate the change in commercial VMT.

The resulting changes in highway performance are summarized in Table 36. In comparing scenarios T-1 and T-5 it is evident that the increasing of the axle weight limits has only a small adverse effect on the performance of the principal arterial systems, however, the increase has a significant adverse impact on the lower volume facilities. This is due to the fact that lower volume facilities generally have lighter pavement designs which are more sensitive to increases in axle loads (36), and subsequently, the collector systems will tend to suffer the most from increasing weight limits.

TABLE 36. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-1, T-4, AND T-5.

FUNCTIONAL CLASSIFICATION	SCENARIO T-1	SCENARIO T-4	SCENARIO T-5
RURAL:			
INTERSTATE	-11.2	-4.2	-11.1
OTHER PRINCIPAL ARTERIALS	-5.8	+1.8	-5.9
MINOR ARTERIALS	-9.6	-1.1	-10.3
MAJOR COLLECTORS	-22.5	-8.4	-27.7
MINOR COLLECTORS	-29.6	-17.7	-33.4
URBAN:			
INTERSTATE	-13.5	-4.4	-15.0
OTHER FREEWAYS AND EXPRESSWAYS	-14.4	-9.5	-15.3
OTHER PRINCIPAL ARTERIALS	-10.4	-6.7	-11.9
MINOR ARTERIALS	-19.3	-15.6	-22.4
COLLECTORS	-18.5	-10.3	-22.9

Option 6

The purpose of this option was to evaluate the effects that a relaxation of present highway performance standards will have on future Indiana highway performance. This relaxation was achieved by attaching more importance to pavement conditions and less importance to volume/capacity ratios and lane widths. Table 37 presents a summary of the weighting values resulting from relaxed performance standards. Such a relaxation in standards would permit the state to concentrate more of its capital funds on pavement rehabilitation and less funds on costly widening improvements.

This option also included the assumption of the 1980 implementation of an 11 cent per gallon gas tax. It was further assumed that non-local capital funds would be distributed among functional classifications by the series II distribution which allocates a greater share of capital funds to lower volume facilities. The resulting impacts on Indiana highway performance are summarized in Table 38. In comparing scenarios T-2 and T-6 it is apparent that there is a general improvement in the performance deterioration of the latter. The relaxation of standards enables the performance losses of the T-6 high volume facilities to be comparable to the T-2 losses on such facilities despite the fact that less funds were allocated to these facilities under the series II distribution. Overall, the pavement conditions are improved considerably under this option; as it can be expected. However, the volume/capacity ratios generally are higher indicating a greater service loss.

TABLE 37. REVISED URBAN AND RURAL CONDITION INDEX WEIGHTS BY FUNCTIONAL CLASSIFICATION.

URBAN WEIGHTS

	PRINCIPAL ARTERIALS	MINOR ARTERIALS	COLLECTORS
CONDITION:			
PAVEMENT TYPE	10	10	10
PAVEMENT COND.	45	55	55
SERVICE:			
VOL/CAP RATIO	30	20	20
SAFETY:			
LANE WIDTH	15	15	15

RURAL WEIGHTS

	PRINCIPAL ARTERIALS	MINOR ARTERIALS	COLLECTORS
CONDITION:			
PAVEMENT TYPE	10	10	10
PAVEMENT COND.	45	55	65
SERVICE:			
VOL/CAP RATIO	30	20	10
SAFETY:			
LANE WIDTH	15	15	15

TABLE 38. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-2, T-6, AND P-6.

FUNCTIONAL CLASSIFICATION	SCENARIO T-2	SCENARIO T-6	SCENARIO P-6
RURAL:			
INTERSTATE	-10.0	-4.5	-2.5
OTHER PRINCIPAL ARTERIALS	-3.1	-5.7	-4.9
MINOR ARTERIALS	-5.8	-6.5	-5.4
MAJOR COLLECTORS	-18.6	-9.4	-8.1
MINOR COLLECTORS	-27.0	-19.8	-21.2
URBAN:			
INTERSTATE	-10.7	-11.3	-10.1
OTHER FREEWAYS AND EXPRESSWAYS	-12.5	-13.0	-9.8
OTHER PRINCIPAL ARTERIALS	-9.7	-9.9	-7.7
MINOR ARTERIALS	-18.8	-16.6	-14.3
COLLECTORS	-15.6	-6.5	-4.4

This option was also run with the PESSIMLONG macroeconomic model to evaluate economic impacts under the revised performance standards. The economic impact results for high volume facilities were much the same as the results observed in Option 1. This indicates that the reduced volume/capacity ratios and commercial VMT values associated with the PESSIMLONG model offset the effects of decreases in capital investments. However, in the lower volume facilities, which generally require more frequent resurfacing, the additional funds allocated to resurfacing improvements with the TRENDLONG model result in significantly improved pavement conditions. This, when considering the increased emphasis on pavement conditions in the series II performance criteria, offsets the lower volume/capacity ratios and commercial VMT values observed with the PESSIMLONG model to a greater degree than was the case with the higher volume facilities. Consequently, the difference in the performance impacts of the two economic models is less conclusive on lower volume facilities. In the case of rural minor collectors, for example, scenario T-6 resulted in better overall pavement condition than those in scenario P-6 and, although the volume/capacity ratios were higher in the former, the overall adverse effect on highway performance was less.

Option 7

This option was intended to evaluate the impacts that a reduction in the present peaking characteristics would have on Indiana highway performance. Such reductions can result from car/van pooling,

staggered working hours and so on. It was assumed in this option that the eleven cent per gallon gas tax would be implemented in 1980, the initial performance standards would be in use, and the series II capital outlay distribution would be utilized. In addition, from 1976 to 1990 a 20 percent reduction in the percent of the average daily travel (ADT) occurring during peak periods was applied.

This option resulted in an improved highway performance; the performance levels were considerably higher than those obtained under scenario T-2 which assumed a continuation of present peaking characteristics. This improvement results from the obvious reductions in volume/capacity ratios and the improvement in pavement conditions as more funds were allocated to pavement rehabilitation as the need for widening diminished (see Table 39).

The increased emphasis on pavement rehabilitation resulted in better pavement conditions under scenario T-7 than those in scenario P-7 despite the lower axle load accumulations in the latter. However, the higher volume/capacity ratios of scenario T-7 and their relative importance in estimating highway performance, offsets the improved pavement conditions, and subsequently, highway performance losses were generally less under scenario P-7.

Implications of the Results

It is apparent from the options tested in this chapter, that a general decline in Indiana highway performance can be expected in the future. Alternatives other than additional revenue generation such as the relaxations of performance standards and reductions in peaking

TABLE 39. SUMMARY OF THE PERCENT CHANGE IN CONDITION INDICES (1976-1990) UNDER SCENARIOS T-2, T-7, AND P-7.

FUNCTIONAL CLASSIFICATION	SCENARIO T-2	SCENARIO T-7	SCENARIO P-7
RURAL:			
INTERSTATE	-10.0	-2.8	-1.1
OTHER PRINCIPAL ARTERIALS	-3.1	-2.6	-1.0
MINOR ARTERIALS	-5.8	-1.8	-0.6
MAJOR COLLECTORS	-18.6	-6.5	-8.1
MINOR COLLECTORS	-27.0	-14.9	-10.9
URBAN:			
INTERSTATE	-10.7	-8.0	-6.2
OTHER FREEWAYS AND EXPRESSWAYS	-12.5	-6.0	-4.4
OTHER PRINCIPAL ARTERIALS	-9.7	-5.3	-3.8
MINOR ARTERIALS	-18.8	-12.4	-9.3
COLLECTORS	-15.6	-8.1	-2.7

characteristics can minimize future highway performance losses as options six and seven indicate. Realistically, a combination of increased taxes and other non-revenue generating alternatives will likely provide the most acceptable solution to the highway financing problem. This combination will be dependent upon public willingness to accept additional taxation and public tolerance to additional highway performance loss.

Insofar as taxation is concerned, the 20 percent ad valorem gas tax is the most promising option tested in this study, as it neutralizes much of the inflationary pressure afflicting highway disbursements. Regretably, administrative problems and public resistance to an apparently high taxing level may make the implementation of such a tax difficult. An increase in the conventional eight cent per gallon gas tax is a more likely source of additional revenue.

The determination of what the public considers to be a tolerable level of highway performance is difficult, if not impossible to assess. It, therefore, can be argued that the relaxation of performance standards considered in option six, which significantly reduced highway performance loss, may be quite acceptable to the public. There is obviously the need for additional research to determine public willingness to accept trade-offs between the safety, service, and condition attributes of highway performance. Other policies such as the reduction in peaking characteristics, through an effective car/van pool program and other such measures, require public cooperation which will be influenced to a certain extent by government incentives.

In conclusion, although highway performance is likely to decrease in the future, appropriate highway policy decisions can assure that an acceptable level of highway performance is achieved.

CHAPTER 9

SUMMARY AND CONCLUSIONS

This research has considered the interaction between factors such as energy, national economic conditions, fuel efficiency, fuel consumption, population, and legislative options in an effort to evaluate their ultimate impact on the highway financing process in Indiana. This evaluation was achieved by the development of a computer model which utilized the national energy and economic forecasts provided by Data Resources Inc. along with various assumptions relating to legislative options to project a probable range of highway performance in Indiana. The results of the application of this model indicate that the level of Indiana highway performance is likely to decline over the next decade as the funds required to sustain highway performance are staggering. However, appropriate legislative action can limit this decline and assure that an acceptable level of highway performance is realized in the future.

On the basis of the results of the present study the following conclusions can be made.

1. Additional highway revenues must be acquired soon as the continued deferment of needed capital improvement projects will seriously compound future highway problems in Indiana. Such additional revenues can be generated from a number of

sources including additional appropriations from general funds and increases in current fuel tax rates or the enactment of an ad valorem fuel tax.

2. Serious efforts should be made to limit the growth in all non-capital highway disbursements.

3. It is necessary to determine the acceptable trade-offs between highway performance components and the capital funding effort should be adjusted accordingly. For example, public outcry over the condition of pavements may seem to indicate the need for more emphasis on pavement rehabilitation. However, if this is to be done,less resources will be available for widening and other such upgrading improvements causing more congested highways. Therefore, careful evaluation must be made of the appropriate trade-offs such that capital improvement funds can be optimally utilized.

4. Attention should be given on statewide promotion of car/van pooling, public transit, and staggered working hours since the effective implementation of these measures may significantly reduce highway congestion in urban areas. This would allow the capital improvement funds normally spent to increase highway capacity to be allocated to pavement rehabilitation and other less costly improvements.

5. Future increases in permissible axle loads should not be considered unless accompanied by significant increases in truck registration fees, since there is evidence that pavement deterioration rates increase measurably under the higher axle load limits.

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APPENDICES

APPENDIX A

Program Listing of the HIPERFORM Computer Model

```
C        * * * * * * * * * * * * * * * * * * * * * * * * * *
C        *                                                   *
C        *                    HIPERFORM I                    *
C        *                                                   *
C        *     HIGHWAY PERFORMANCE FORECASTING MODEL         *
C        *     VERSION I                                     *
C        *                                                   *
C        *                                                   *
C        *     DEVELOPED BY  F. MANNERING                    *
C        *                                                   *
C        *     PURDUE UNIVERSITY                             *
C        *     MARCH 1979                                    *
C        *                                                   *
C        * * * * * * * * * * * * * * * * * * * * * * * * * *
C
C
C
C
C
      PROGRAM MAIN(INPUT,OUTPUT,TLONG78,TAPE5,TAPE6)
      DIMENSION RINC(15),SINC(15),TOMG(15),BI(15),MIN(30),GPI(15),
     1MP15(30),ITGAS(15),IRECO(15),IRESU(15),IREMO(15),IREA(15),
     2RV1(15),RV2(15),GRATE1(16),GRATE2(16),ITREV(16),HG4(3,5,105)
     3,HG5(3,6,105),HGWY(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)
     4,AID(15),WSIN(16),TAX(15)
      COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,
     1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IVOL,GRATE1,GRATE2,ITREV
     2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN
      KSSF=1
      KSFLAG=1
      READ(5,1000) KSEED,KCOW
 1000 FORMAT(I6,1X,I2)
      DO 1979 I=1,KSEED
 1979 SEED=RANF(0)
      READ(5,503) (AID(I),I=1,15)
  503 FORMAT(15F4.2)
      READ(5,501) (WSIN(I),I=1,15)
  501 FORMAT(15F5.1)
      READ(5,1010) (RV1(I),I=1,15)
      READ(5,1010) (RV2(I),I=1,15)
 1010 FORMAT(15F4.2)
      DO 3000 N1=1,KCOW
      KBARR=N1
      IF(N1.EQ.KCOW) KSSF=2
      IF(N1.GT.1) KSFLAG=2
      CALL PRESCO
      IF(N1.GT.1) GO TO 510
      CALL IPPM
      CALL USACO
      CALL VMPRO
      CALL REVGEN
  510 CALL PAVAGE
 3000 CONTINUE
      STOP
      END
C
```

HPM 1
HPM 2
HPM 3
HPM 4
HPM 5
HPM 6
HPM 7
HPM 8
HPM 9
HPM 10
HPM 11
HPM 12
HPM 13
HPM 14
HPM 15
HPM 16
HPM 17
HPM 18
HPM 19
HPM 20
HPM 21
HPM 22
HPM 23
HPM 24
HPM 25
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HPM 36
HPM 37
HPM 38
HPM 39
HPM 40
HPM 41
HPM 42
HPM 43
HPM 44
HPM 45
HPM 46
HPM 47
HPM 48
HPM 49
HPM 50
HPM 51
HPM 52
HPM 53
HPM 54
HPM 55
HPM 56
HPM 57
HPM 58
HPM 59
HPM 60

```
C                                                                       HPM   61
C                                                                       HPM   62
C                                                                       HPM   63
C                                                                       HPM   64
      SUBROUTINE IPPM                                                   HPM   65
C ***********************************************************************HPM   66
C                                                                       HPM   67
C                                                                       HPM   68
C          THIS SUBROUTINE PROJECTS THE INDIANA POPULATION TO THE       HPM   69
C          TARGET YEAR.                                                 HPM   70
C                                                                       HPM   71
C                                                                       HPM   72
      DIMENSION MAL(18),MFE(18),SUM1(18),SUM2(18),SUF1(18),SUF2(18),    HPM   73
     1SF(6),SUMM(18),SUFM(18),SUM3(6,18),SUF3(6,18),RMIG(6),MAL1(18),   HPM   74
     2MFE1(18),N1(6),MMA(30),MMF(30),MIN(30),RINC(15),SINC(15),TOMG(15) HPM   75
     3,BI(15),GPI(15),WMIG(4),MP15(30),ITGAS(15),IRECO(15),             HPM   76
     4IRESU(15),IREMO(15),IREA(15),RV1(15),RV2(15),HG4(3,5,105)         HPM   77
     5,HG5(3,6,105),HGWY(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)   HPM   78
     6,GRATE1(16),GRATE2(16),ITREV(16),AID(15),WSIN(16),TAX(15)         HPM   79
      COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,               HPM   80
     1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IVOL,GRATE1,GRATE2,ITREVHPM   81
     2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN        HPM   82
C                                                                       HPM   83
C **** READ SERIES                                                      HPM   84
C                                                                       HPM   85
      READ(5,9999) IVOL,NYEAR,SAT1                                      HPM   86
 9999 FORMAT(I1,1X,I2,1X,F4.2)                                          HPM   87
C                                                                       HPM   88
C **** INITIAL COHORTS                                                  HPM   89
C                                                                       HPM   90
      DATA(MAL1(I),I=1,18)/232479,268759,278959,253127,195629,171449,   HPM   91
     A144834,136324,148231,147852,132652,118207,98179,74348,55881,      HPM   92
     B38238,22028,13994/                                                HPM   93
      DATA(MFE1(I),I=1,18)/223197,260265,266944,249113,219095,174413,   HPM   94
     A148775,143141,154703,156684,141669,125775,109405,92145,76349,     HPM   95
     B57775,37124,25927/                                                HPM   96
C                                                                       HPM   97
C **** INPUT SURVIVAL RATES                                             HPM   98
C                                                                       HPM   99
      DATA(SUM1(I),I=1,18)/.980568,.996687,.998061,.995056,.990373,     HPM  100
     A.989901,.990559,.988505,.983123,.972836,.957040,.933383,.899862,  HPM  101
     B.852301,.790463,.710259,.605016,.406879/                          HPM  102
      DATA(SUM2(I),I=1,18)/.98475,.996936,.998191,.995322,.99081,.99056 HPM  103
     A6,.991379,.98968,.985007,.975772,.961179,.938696,.906192,.859358, HPM  104
     B.797309,.719784,.621615,.42339/                                   HPM  105
      DATA(SUF1(I),I=1,18)/.984689,.997442,.998523,.997784,.996683,     HPM  106
     A.996368,.995455,.993414,.989939,.984169,.976437,.965977,.95087,   HPM  107
     B.930779,.895951,.832189,.733118,.496489/                          HPM  108
      DATA(SUF2(I),I=1,18)/.987952,.997738,.99866,.998019,.997054,      HPM  109
     A.996834,.996033,.994246,.991076,.985895,.978952,.969318,.955584,  HPM  110
     B.937323,.905365,.847452,.754904,.508305/                          HPM  111
C                                                                       HPM  112
C **** FERTILITY RATES                                                  HPM  113
C                                                                       HPM  114
      DATA(SF(I),I=1,6)/71.5,70.,69.1,67.1,64.7,60.1/                   HPM  115
C                                                                       HPM  116
C **** ESTIMATED MIGRATION RATES                                        HPM  117
C                                                                       HPM  118
      DATA(RMIG(I),I=1,6)/-.018,-.021,-.009,-.005,-.005,-.005/          HPM  119
C                                                                       HPM  120
C **** DETERMINE SURVIVAL RATE INCREASE                                 HPM  121
C                                                                       HPM  122
      DO 7070 I=1,18                                                    HPM  123
      SUMM(I)=(SUM2(I)-SUM1(I))/4                                       HPM  124
 7070 SUFM(I)=(SUF2(I)-SUF1(I))/4                                       HPM  125
      DO 7077 I=1,2                                                     HPM  126
      DO 7077 N=1,18                                                    HPM  127
      SUM3(I,N)=SUM1(N)                                                 HPM  128
 7077 SUF3(I,N)=SUF1(N)                                                 HPM  129
      DO 7078 I=3,6                                                     HPM  130
```

```
      DO 7078 N=1,18                                                    HPM  131
      SUM3(I,N)=SUM1(N)+((I-2)*SUMM(N))                                 HPM  132
 7078 SUF3(I,N)=SUF1(N)+((I-2)*SUFM(N))                                 HPM  133
C                                                                       HPM  134
C **** START OF YEARLY PROJECTIONS                                      HPM  135
C                                                                       HPM  136
      DO 8182 I=1,18                                                    HPM  137
      MAL(I)=MAL1(I)                                                    HPM  138
 8182 MFE(I)=MFE1(I)                                                    HPM  139
      DO 8080 L=1,6                                                     HPM  140
      IYEAR=1975+(L-1)*5                                                HPM  141
      N1(L)=5*L                                                         HPM  142
C                                                                       HPM  143
C **** BIRTH CALCULATIONS                                               HPM  144
C                                                                       HPM  145
      FER2=0                                                            HPM  146
      DO 7071 I=4,9                                                     HPM  147
      FER1=FLOAT(MFE(I)/1000)*SF(L)                                     HPM  148
 7071 FER2=FER2+FER1                                                    HPM  149
      FER2=FER2*5                                                       HPM  150
C                                                                       HPM  151
C **** SURVIVAL CALCULATIONS                                            HPM  152
C                                                                       HPM  153
      DO 7072 I=1,18                                                    HPM  154
      MAL(I)=IFIX(FLOAT(MAL(I))*SUM3(L,I))                              HPM  155
 7072 MFE(I)=IFIX(FLOAT(MFE(I))*SUF3(L,I))                              HPM  156
C                                                                       HPM  157
C **** COHORT ADVANCE                                                   HPM  158
C                                                                       HPM  159
      MALV=MAL(18)                                                      HPM  160
      MFEV=MAL(18)                                                      HPM  161
      DO 7073 I=1,17                                                    HPM  162
      J=18-I                                                            HPM  163
      MAL(J+1)=MAL(J)                                                   HPM  164
 7073 MFE(J+1)=MFE(J)                                                   HPM  165
      MAL(18)=MAL(18)+MALV                                              HPM  166
      MFE(18)=MFE(18)+MFEV                                              HPM  167
      MAL(1)=IFIX(.515*FER2)                                            HPM  168
      MFE(1)=IFIX(.485*FER2)                                            HPM  169
C                                                                       HPM  170
C **** MIGRATION CALCULATIONS                                           HPM  171
C                                                                       HPM  172
      DO 7075 I=1,18                                                    HPM  173
      MAL(I)=IFIX(FLOAT(MAL(I))*1.05*RMIG(L))+MAL(I)                    HPM  174
 7075 MFE(I)=IFIX(FLOAT(MFE(I))*.95*RMIG(L))+MFE(I)                     HPM  175
      MALT=0                                                            HPM  176
      MFET=0                                                            HPM  177
      DO 7074 I=1,18                                                    HPM  178
      MALT=MALT+MAL(I)                                                  HPM  179
      MFET=MFET+MFE(I)                                                  HPM  180
 7074 IF(I.GE.4) MP15(N1(L))=MP15(N1(L))+MAL(I)+MFE(I)                  HPM  181
      INPOP=MALT+MFET                                                   HPM  182
      MMA(N1(L))=MALT                                                   HPM  183
      MMF(N1(L))=MFET                                                   HPM  184
      MIN(N1(L))=INPOP                                                  HPM  185
      IF(L.EQ.1) GO TO 8080                                             HPM  186
      MACO=(MMA(N1(L))-MMA(N1(L-1)))/5                                  HPM  187
      MFCO=(MMF(N1(L))-MMF(N1(L-1)))/5                                  HPM  188
      INCO=(MIN(N1(L))-MIN(N1(L-1)))/5                                  HPM  189
      IF(L.NE.2) GO TO 90                                               HPM  190
      WMIG(1)=.995                                                      HPM  191
      WMIG(2)=.9973                                                     HPM  192
      WMIG(3)=1.                                                        HPM  193
      WMIG(4)=1.003                                                     HPM  194
      GO TO 92                                                          HPM  195
   90 DO 91 I=1,4                                                       HPM  196
   91 WMIG(I)=1.                                                        HPM  197
   92 DO 1900 I=1,4                                                     HPM  198
      J=N1(L-1)+I                                                       HPM  199
      MMA(J)=(MACO+MMA(J-1))*WMIG(I)                                    HPM  200
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```
      MMF(J)=(MFCO+MMF(J-1))*WMIG(I)                                    HPM  201
 1900 MIN(J)=(INCO+MIN(J-1))*WMIG(I)                                    HPM  202
 8080 CONTINUE                                                          HPM  203
      WRITE(6,1000)                                                     HPM  204
 1000 FORMAT('1',1X,25('* '),1X,'INDIANA POPULATION ESTIMATES',1X,25('* HPM  205
     A'),/////,31X,71('-'),//,31X'YEAR',15X,'FEMALE',16X,'MALE',        HPM  206
     B16X,'TOTAL',/,31X,71('-'),/)                                      HPM  207
      NDO=NYEAR+5                                                       HPM  208
      DO 1901 I=6,NDO                                                   HPM  209
      J=I-5                                                             HPM  210
      IYEAR=1975+J                                                      HPM  211
      WRITE(6,1001) IYEAR,MMF(I),MMA(I),MIN(I)                          HPM  212
 1001 FORMAT(31X,I4,3(12X,I9),/)                                        HPM  213
 1901 CONTINUE                                                          HPM  214
      WRITE(6,1002)                                                     HPM  215
 1002 FORMAT(31X,71('-'))                                               HPM  216
      RETURN                                                            HPM  217
      END                                                               HPM  218
C                                                                       HPM  219
C                                                                       HPM  220
C                                                                       HPM  221
C                                                                       HPM  222
C                                                                       HPM  223
      SUBROUTINE USACO                                                  HPM  224
C *********************************************************************** HPM  225
C                                                                       HPM  226
C                                                                       HPM  227
C          THIS SUBROUTINE ESTIMATES NATIONAL AUTO FLEET FUEL           HPM  228
C          EFFICIENCIES.                                                HPM  229
C                                                                       HPM  230
C                                                                       HPM  231
      DIMENSION PSR(25),ACOR(12),SURV(12),RMPG(12),FMPG(15),            HPM  232
     1UNEM(15),RGNP(15),RINC(15),ZNCP(15),TOMG(15),                     HPM  233
     2NCB(15),BCOR(12),BI(15),TUT(15),PERV(15),MP15(30),                HPM  234
     3MIN(30),SINC(15),GPI(15),RV1(15),RV2(15),TAX(15),                 HPM  235
     4ITGAS(15),IRECO(15),IRESU(15),IREMO(15),IREA(15),GRATE1(16),      HPM  236
     5GRATE2(16),ITREV(16),HG4(3,5,105),GPI1(15),AID(15),WSIN(16)       HPM  237
     6,HG5(3,6,105),HGWY(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)    HPM  238
      COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,               HPM  239
     1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IVOL,GRATE1,GRATE2,ITREVHPM  240
     2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN        HPM  241
      INTEGER ACOR,BCOR,NCB,TAUTO,PDIFF,BACOR,CACOR,TUT,PSIX,RACOR      HPM  242
     1,UAUTO                                                            HPM  243
C                                                                       HPM  244
C **** READ INPUT DATA                                                  HPM  245
C                                                                       HPM  246
      READ(5,1001) (RINC(I),I=1,NYEAR)                                  HPM  247
      READ(5,1001) (GPI1(I),I=1,NYEAR)                                  HPM  248
      READ(5,1002) (RGNP(I),I=1,NYEAR)                                  HPM  249
      READ(5,1002) (BI(I),I=1,NYEAR)                                    HPM  250
      READ(5,1002) (SINC(I),I=1,NYEAR)                                  HPM  251
 1001 FORMAT (15(F5.1))                                                 HPM  252
 1002 FORMAT (15(F6.1))                                                 HPM  253
      DATA(PSR(I),I=1,25)/213.5,215.12,216.75,218.44,220.23,222.16,     HPM  254
     A224.21,226.34,228.51,230.69,232.88,235.06,237.23,239.36,241.46,   HPM  255
     B243.51,245.5,247.43,249.28,251.05,252.75,254.38,255.95,257.56,    HPM  256
     C258.93/                                                           HPM  257
      DATA(ACOR(I),I=1,12)/4684,9763,11332,10098,8549,8341,8339,7556,   HPM  258
     A6113,5796,4825,9824/                                              HPM  259
      DATA(SURV(I),I=1,12)/1.52,1.,.995,.992,.982,.968,.953,.923,.887,  HPM  260
     A.845,.713,.80/                                                    HPM  261
      DATA(RMPG(I),I=1,12)/14.5,13.,,12.8,13.0,13.3,13.4,13.5,13.7      HPM  262
     A,13.9,14.2,14.3,14.3/                                             HPM  263
      DATA(FMPG(I),I=1,10)/15.5,17.,18.,19.,20.,21.5,23.,24.5,26.,      HPM  264
     A27.5/                                                             HPM  265
      B9=(2.0-SAT1)/ALOG(25.)                                           HPM  266
C                                                                       HPM  267
C **** INITIAL PARAMETER VALUES                                         HPM  268
C                                                                       HPM  269
      USIN=169.7                                                        HPM  270
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      UV2=.51                                                          HPM  271
C                                                                      HPM  272
C **** PROJECTIONS OF ECONOMIC PARAMETERS                              HPM  273
C                                                                      HPM  274
      DO 1800 I=1,NYEAR                                                HPM  275
      IF(IVOL.EQ.2) GO TO 400                                          HPM  276
      UV1=UV2*(1.+GPI1(I)/100.)+RV1(I)                                 HPM  277
      UV2=UV1-RV1(I)                                                   HPM  278
  401 GPI(I)=UV1*USIN/.59                                              HPM  279
      GO TO 1800                                                       HPM  280
  400 UV1=(UV2-.04)*(1.+GPI1(I)/100.)*(1.+RV2(I))+.04                  HPM  281
      UV2=UV1-((UV2-.04)*(1.+GPI1(I)/100.)*(RV2(I)))                   HPM  282
      TAX(I)=(UV2-.04)*(1.+GPI1(I)/100.)*RV2(I)                        HPM  283
      GO TO 401                                                        HPM  284
 1800 CONTINUE                                                         HPM  285
      DO 1903 N=1,NYEAR                                                HPM  286
      TACOR=0                                                          HPM  287
      DO 1901 I=1,12                                                   HPM  288
 1901 TACOR=TACOR+ACOR(I)                                              HPM  289
C                                                                      HPM  290
C **** ESTIMATION OF NUMBER OF NEW CARS PURCHASED                      HPM  291
C                                                                      HPM  292
      NCB(N)=IFIX(RINC(N)*1000./1.55)                                  HPM  293
C                                                                      HPM  294
C **** SURVIVAL RATE CALCULATIONS                                      HPM  295
C                                                                      HPM  296
      DO 1904 I=1,12                                                   HPM  297
 1904 BCOR(I)=ACOR(I)*SURV(I)                                          HPM  298
      CACOR=BCOR(12)                                                   HPM  299
C                                                                      HPM  300
C **** SURVIVAL RATE ADJUSTMENTS                                       HPM  301
C                                                                      HPM  302
      UAUTO=IFIX(RGNP(N)*1000.)                                        HPM  303
      IAUTO=0                                                          HPM  304
      DO 2003 I=1,12                                                   HPM  305
 2003 IAUTO=BCOR(I)+IAUTO                                              HPM  306
      IVARZ=IAUTO+NCB(N)                                               HPM  307
C                                                                      HPM  308
C **** ESTIMATING SURVIVAL RATE CHANGES                                HPM  309
C                                                                      HPM  310
      PDIFF=UAUTO-IVARZ                                                HPM  311
      ICOUNT=0                                                         HPM  312
      INT=0                                                            HPM  313
      IF(PDIFF.LT.0) GO TO 2017                                        HPM  314
      ISTAB=1                                                          HPM  315
 2005 ION=ISTAB                                                        HPM  316
      R1=RANF(0)                                                       HPM  317
      ICOUNT=ICOUNT+1                                                  HPM  318
      IF(ICOUNT.NE.7) GO TO 2002                                       HPM  319
      ION=-ISTAB                                                       HPM  320
      ICOUNT=0                                                         HPM  321
 2002 IF(R1.LE.0.15) BCOR(1)=BCOR(1)+ION                               HPM  322
      IF(R1.GT.0.15.AND.R1.LE.0.2) BCOR(2)=BCOR(2)+ION                 HPM  323
      IF(R1.GT.0.2.AND.R1.LE.0.225) BCOR(3)=BCOR(3)+ION                HPM  324
      IF(R1.GT.0.225.AND.R1.LE.0.252) BCOR(4)=BCOR(4)+ION              HPM  325
      IF(R1.GT.0.252.AND.R1.LE.0.286) BCOR(5)=BCOR(5)+ION              HPM  326
      IF(R1.GT.0.286.AND.R1.LE.0.329) BCOR(6)=BCOR(6)+ION              HPM  327
      IF(R1.GT.0.329.AND.R1.LE.0.383) BCOR(7)=BCOR(7)+ION              HPM  328
      IF(R1.GT.0.383.AND.R1.LE.0.455) BCOR(8)=BCOR(8)+ION              HPM  329
      IF(R1.GT.0.455.AND.R1.LE.0.549) BCOR(9)=BCOR(9)+ION              HPM  330
      IF(R1.GT.0.549.AND.R1.LE.0.67) BCOR(10)=BCOR(10)+ION             HPM  331
      IF(R1.GT.0.67.AND.R1.LE.0.805) BCOR(11)=BCOR(11)+ION             HPM  332
      IF(R1.GT.0.805) BCOR(12)=BCOR(12)+ION                            HPM  333
      INT=INT+ION                                                      HPM  334
      IAM=IABS(INT-PDIFF)                                              HPM  335
      IF(IAM.LE.1) GO TO 2004                                          HPM  336
      GO TO 2005                                                       HPM  337
 2017 ISTAB=-1                                                         HPM  338
      GO TO 2005                                                       HPM  339
 2004 DO 2011 I=1,12                                                   HPM  340
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 2011 SURV(I)=FLOAT(BCOR(I))/FLOAT(ACOR(I))                                    HPM  341
C                                                                              HPM  342
C **** COHORT ADVANCE                                                          HPM  343
C                                                                              HPM  344
      DO 1905 I=1,11                                                           HPM  345
      J=12-I                                                                   HPM  346
 1905 BCOR(J+1)=BCOR(J)                                                        HPM  347
      BACOR=BCOR(12)                                                           HPM  348
      BCOR(1)=NCB(N)                                                           HPM  349
      BCOR(12)=BACOR+CACOR                                                     HPM  350
      TAUTO=0                                                                  HPM  351
      DO 1992 I=1,12                                                           HPM  352
 1992 TAUTO=TAUTO+BCOR(I)                                                      HPM  353
      TUT(N)=TAUTO                                                             HPM  354
      DO 1910 I=1,12                                                           HPM  355
 1910 ACOR(I)=BCOR(I)                                                          HPM  356
C                                                                              HPM  357
C **** FLEET MILEAGE CALCULATIONS                                              HPM  358
C                                                                              HPM  359
      RMPG(12)=(FLOAT(BACOR)*RMPG(11)+FLOAT(CACOR)*RMPG(12))/FLOAT(BCOR(HPM  360
     A12))                                                                     HPM  361
      DO 1911 I=2,11                                                           HPM  362
      J=12-I                                                                   HPM  363
 1911 RMPG(J+1)=RMPG(J)                                                        HPM  364
      IF(N.GT.10) FMPG(N)=27.5                                                 HPM  365
      RMPG(1)=FMPG(N)                                                          HPM  366
      TMPG=0                                                                   HPM  367
      TTG1=0                                                                   HPM  368
      DO 1912 I=1,12                                                           HPM  369
      C1=FLOAT(I+1)                                                            HPM  370
      R7=1.8535-.48126*ALOG(C1)                                                HPM  371
      IF(I.EQ.1) R7=.9                                                         HPM  372
      TTG1=FLOAT(BCOR(I))*R7+TTG1                                              HPM  373
 1912 TMPG=TMPG+(FLOAT(BCOR(I))*RMPG(I)*R7)                                    HPM  374
      TOMG(N)=TMPG/TTG1                                                        HPM  375
      PPVL=PSR(N+1)*1000/FLOAT(TUT(N))                                         HPM  376
      PERV(N)=PPVL                                                             HPM  377
 1903 CONTINUE                                                                 HPM  378
C                                                                              HPM  379
C **** OUTPUT STATEMENTS                                                       HPM  380
C                                                                              HPM  381
      WRITE(6,101)                                                             HPM  382
  101 FORMAT('1',1X,24('* '),1X,'U.S. AUTO EFFICIENCY PROJECTIONS',1X,         HPM  383
     A24('* '),////,16X,96('-'),/,35X,'NEW CAR',14X,'TOTAL NUMBER',14X,       HPM  384
     B'FLEET',15X,'PERSONS',/,16X,'YEAR',15X,'SALES 1/',14X,'OFTAUTOS 1/HPM  385
     C',15X,'MPG',15X,'PER AUTO',/,16X,96('-'),/)                              HPM  386
      DO 1913 I=1,NYEAR                                                        HPM  387
      NOY=1975+I                                                               HPM  388
      NSIN=IFIX(RINC(I)*1000.)                                                 HPM  389
      WRITE(6,102) NOY,NSIN,TUT(I),TOMG(I),PERV(I)                             HPM  390
  102 FORMAT(16X,I4,15X,I6,17X,I7,17X,F5.2,15X,F5.2,/)                         HPM  391
 1913 CONTINUE                                                                 HPM  392
      WRITE(6,103)                                                             HPM  393
  103 FORMAT(16X,96('-'))                                                      HPM  394
      WRITE(6,104)                                                             HPM  395
  104 FORMAT(//,16X,'1/ IN THOUSANDS')                                         HPM  396
      RETURN                                                                   HPM  397
      END                                                                      HPM  398
C                                                                              HPM  399
C                                                                              HPM  400
C                                                                              HPM  401
C                                                                              HPM  402
C                                                                              HPM  403
      SUBROUTINE VMPRO                                                         HPM  404
C ***************************************************************************** HPM  405
C                                                                              HPM  406
C                                                                              HPM  407
C          THIS SUBROUTINE PROJECTS VEHICLE MILES OF TRAVEL IN                 HPM  408
C          INDIANA BY VEHICLE TYPE.                                            HPM  409
C                                                                              HPM  410
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C                                                                       HPM  411
      DIMENSION SPRO(15),AITM(15),AIVM(15),ZMPG(15),SUMG(15),           HPM  412
     1BMUG(15),ZMPG1(15),TVMT(15),TGAS(15),                             HPM  413
     3IAUVM(15),IAIVM(15),ITVMT(15),REAUT(15),                          HPM  414
     4RECOM(15),RESU(15),REBUS(15),REMO(15),PPV(15),REGT(15),IREA(15),  HPM  415
     5IRESU(15),IRECO(15),IREGT(15),IREMO(15),RINC(15),SINC(15),TOMG(15)HPM  416
     6,BI(15),MIN(30),ITGAS(15),IAITM(15),GPI(15)                       HPM  417
     7,ZVAR(15),MP15(30),RV1(15),RV2(15),GRATE1(16),GRATE2(16)          HPM  418
     8,ITREV(16),HG4(3,5,105),AID(15),WSIN(16),TAX(15)                  HPM  419
     9,HG5(3,6,105),HGWY(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)    HPM  420
      COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,               HPM  421
     1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IVOL,GRATE1,GRATE2,ITREVHPM  422
     2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN        HPM  423
C                                                                       HPM  424
C                                                                       HPM  425
C **** STEEL PRODUCTION ESTIMATES                                       HPM  426
C                                                                       HPM  427
      DO 2000 I=1,NYEAR                                                 HPM  428
      SPRO(I)=1.22*SINC(I)/100.*17.61                                   HPM  429
C                                                                       HPM  430
C **** INTERCITY TON-MILE ESTIMATES                                     HPM  431
C                                                                       HPM  432
      AITM(I)=-51.4764+8.95205*ALOG(BI(I))+8.72447*ALOG(SPRO(I))        HPM  433
 2000 IAITM(I)=IFIX(AITM(I)*1000.)                                      HPM  434
      TVM4=37359.                                                       HPM  435
      TVM3=35459.                                                       HPM  436
      AIVM4=1900.                                                       HPM  437
C                                                                       HPM  438
C **** VEHICLE MILE CALCULATIONS                                        HPM  439
C                                                                       HPM  440
      DO 2002 I=1,NYEAR                                                 HPM  441
      AIVM(I)=1900.*AITM(I)/17.22                                       HPM  442
      GRATE1(I)=(AIVM(I)-AIVM4)/AIVM4                                   HPM  443
      AIVM4=AIVM(I)                                                     HPM  444
      ZMPG1(I)=AIVM(I)/(5.69*((1.018)**I))                              HPM  445
      SUMG(I)=10.01*(1.008**I)                                          HPM  446
      BMUG(I)=5.28*(1.006**I)                                           HPM  447
      XX1=.17*(1.005**I)                                                HPM  448
      XX2=.004*(1.005**I)                                               HPM  449
      XX3=1.-(.017+XX1+XX2)                                             HPM  450
      BVAR=XX1/SUMG(I)+XX3/TOMG(I)+XX2/BMUG(I)+.017/50.                 HPM  451
      DELGP=-1.+GPI(I)/169.7                                            HPM  452
      TVMT(I)=TVM4*(1.033)**I*(1-.10*DELGP)                             HPM  453
      GRATE2(I)=((TVMT(I)-AIVM(I))-TVM3)/TVM3                           HPM  454
      TVM3=TVMT(I)-AIVM(I)                                              HPM  455
      ZMPG(I)=TVMT(I)/(ZMPG1(I)+(TVMT(I)-AIVM(I))*BVAR)                 HPM  456
C                                                                       HPM  457
C **** FUEL CONSUMPTION CALCULATIONS                                    HPM  458
C                                                                       HPM  459
      ZVAR(I)=TVMT(I)-AIVM(I)                                           HPM  460
      TGAS(I)=(TVMT(I)/ZMPG(I))                                         HPM  461
C                                                                       HPM  462
C **** CONVERSION OF REAL ARRAYS TO INTEGER ARRAYS                      HPM  463
C                                                                       HPM  464
      IAUVM(I)=IFIX(XX3*ZVAR(I))                                        HPM  465
      IAIVM(I)=IFIX(AIVM(I))                                            HPM  466
      ITVMT(I)=IFIX(TVMT(I))                                            HPM  467
 2002 ITGAS(I)=IFIX(TGAS(I))*1000                                       HPM  468
C                                                                       HPM  469
C **** REGISTRATION ESTIMATIONS                                         HPM  470
C                                                                       HPM  471
      DO 2003 I=1,NYEAR                                                 HPM  472
      REAUT(I)=FLOAT(MIN(I+5))/(2.0-B9*ALOG(FLOAT(I)))                  HPM  473
      RECOM(I)=38543.*(1.015)**I*(1+.21*(BI(I)/117.8-1))                HPM  474
      PC2=.27*(1.005**I)                                                HPM  475
      PC3=.0056*(1.0005**I)                                             HPM  476
      RESU(I)=REAUT(I)*PC2                                              HPM  477
      REBUS(I)=PC3*REAUT(I)                                             HPM  478
      REMO(I)=.055*REAUT(I)                                             HPM  479
      PPV(I)=FLOAT(MIN(I+5))/(RESU(I)+REBUS(I)+RECOM(I)+REAUT(I))       HPM  480
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      REGT(I)=REAUT(I)+RECOM(I)+RESU(I)+REBUS(I)                        HPM  481
C                                                                       HPM  482
C **** CONVERSION OF REAL ARRAYS TO INTEGER ARRAYS                      HPM  483
C                                                                       HPM  484
      IREA(I)=IFIX(REAUT(I))                                            HPM  485
      IRESU(I)=IFIX(RESU(I))                                            HPM  486
      IRECO(I)=IFIX(RECOM(I))                                           HPM  487
      IREGT(I)=IFIX(REGT(I))                                            HPM  488
 2003 IREMO(I)=IFIX(REMO(I))                                            HPM  489
C                                                                       HPM  490
C **** OUTPUT STATEMENTS                                                HPM  491
C                                                                       HPM  492
      WRITE(6,1)                                                        HPM  493
    1 FORMAT('1',1X,29('* '),'VMT PROJECTIONS',1X,29('* '),/////,       HPM  494
     A21X,90('-'),/,40X,'AUTO',14X,'COMBINATION',12X,'TOTAL',16X,       HPM  495
     B'FLEET',/,21X,'YEAR',14X,'VMT 1/',15X,'VMT 1/',14X,'VMT 1/',17X,  HPM  496
     C'MPG',/,21X,90('-'),/)                                            HPM  497
      NFLAG=1                                                           HPM  498
    9 DO 2010 I=1,NYEAR                                                 HPM  499
      NOY=1975+I                                                        HPM  500
      DEL=(GPI(I)/169.7)*.59                                            HPM  501
      IF(NFLAG.EQ.2) GO TO 7                                            HPM  502
      IF(NFLAG.EQ.3) GO TO 17                                           HPM  503
      WRITE(6,2) NOY,IAUVM(I),IAIVM(I),ITVMT(I),ZMPG(I)                 HPM  504
    2 FORMAT(21X,I4,14X,I5,2(16X,I5),16X,F5.2,/)                        HPM  505
      GO TO 2010                                                        HPM  506
    7 WRITE(6,4) NOY,IREA(I),IRESU(I),IRECO(I),IREGT(I),PPV(I)          HPM  507
    4 FORMAT(11X,I4,15X,I7,14X,I6,15X,I5,14X,I7,15X,F5.2,/)             HPM  508
      GO TO 2010                                                        HPM  509
   17 WRITE(6,19) NOY,DEL,ITGAS(I),IAITM(I)                             HPM  510
   19 FORMAT(30X,I4,15X,F4.2,17X,I7,17X,I5,/)                           HPM  511
 2010 CONTINUE                                                          HPM  512
      IF(NFLAG.EQ.1) WRITE(6,31)                                        HPM  513
   31 FORMAT(21X,90('-'))                                               HPM  514
      IF(NFLAG.EQ.1) WRITE(6,40)                                        HPM  515
   40 FORMAT(//,21X,'1/ IN MILLIONS OF VEHICLE MILES TRAVELED')         HPM  516
      IF(NFLAG.EQ.2) WRITE(6,32)                                        HPM  517
   32 FORMAT(11X,110('-'))                                              HPM  518
      IF(NFLAG.EQ.3) WRITE(6,33)                                        HPM  519
   33 FORMAT(30X,72('-'))                                               HPM  520
      IF(NFLAG.EQ.3) WRITE(6,41)                                        HPM  521
   41 FORMAT(//,33X,'1/ IN THOUSANDS OF GALLONS')                       HPM  522
      IF(NFLAG.EQ.3) WRITE(6,42)                                        HPM  523
   42 FORMAT(/,33X,'2/ IN MILLIONS')                                    HPM  524
      IF(NFLAG.EQ.3) GO TO 10                                           HPM  525
      IF(NFLAG.EQ.2) GO TO 18                                           HPM  526
      WRITE(6,3)                                                        HPM  527
    3 FORMAT('1',1X,26('* '),'REGISTRATION PROJECTIONS',1X,27('* '),    HPM  528
     A/////,11X,110('-'),/,61X,'TRUCKS',/,31X,'AUTO',13X,'SINGLE UNIT ',HPM  529
     B9X,'COMBINATION ',12X,'TOTAL',14X,'PERSONS',/,11X,'YEAR',         HPM  530
     C11X,'REGISTRATIONS',3(8X,'REGISTRATIONS'),8X,'PER VEHICLE',       HPM  531
     D/,11X,110('-'),/)                                                 HPM  532
      NFLAG=2                                                           HPM  533
      GO TO 9                                                           HPM  534
   18 WRITE(6,20)                                                       HPM  535
   20 FORMAT('1',1X,23('* '),'FUEL CONSUMPTION AND TON-MILE ESTIMATES ' HPM  536
     A,23('* '),/////,30X,72('-'),/,46X,'RETAIL GAS',13X,'MOTOR FUEL',  HPM  537
     B13X,'INTERCITY',/,30X,'YEAR',15X,'PRICE',13X,'CONSUMPTION 1/',9X, HPM  538
     C'TON-MILES 2/',/,30X,72('-'),/)                                   HPM  539
      NFLAG=3                                                           HPM  540
      GO TO 9                                                           HPM  541
   10 RETURN                                                            HPM  542
      END                                                               HPM  543
C                                                                       HPM  544
C                                                                       HPM  545
C                                                                       HPM  546
C                                                                       HPM  547
C                                                                       HPM  548
      SUBROUTINE REVGEN                                                 HPM  549
C ********************************************************************* HPM  550
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C                                                                       HPM  551
C                                                                       HPM  552
C          THIS SUBROUTINE ESTIMATES ALL INDIANA STATE ROAD-USER        HPM  553
C          TAX REVENUES.                                                HPM  554
C                                                                       HPM  555
C                                                                       HPM  556
      DIMENSION MP15(30),ITGAS(15),IRECO(15),IRESU(15),IREMO(15),       HPM  557
     AIREA(15),RIV1(15),RIV2(15),RIV3(15),RV1(15),RV2(15),RINC(15),     HPM  558
     BSINC(15),TOMG(15),BI(15),GPI(15),MIN(30),N1(6),HG4(3,5,105)       HPM  559
     C,1RLP(2,15),PCTT(2,15),GRATE1(16),GRATE2(16),ITREV(16),           HPM  560
     DHG5(3,6,105),HGWY(3,6,105),HG2(3,6,105),ML1(3,6),HG3(3,5,105)     HPM  561
     E,AID(15),WSIN(16),TAX(15)                                         HPM  562
      COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,               HPM  563
     1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IVOL,GRATE1,GRATE2,ITREVHPM  564
     2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN         HPM  565
C                                                                       HPM  566
C **** READ INPUT DATA                                                  HPM  567
C                                                                       HPM  568
      DATA((IRLP(I,J),J=1,15),I=1,2)/16,24,40,65,100,120,175,225,275,   HPM  569
     A325,375,400,425,450,0,0,0,0,0,110,190,235,285,310,360,385,410,    HPM  570
     B435,485,500/                                                      HPM  571
      DATA((PCTT(I,J),J=1,15),I=1,2)/.78,.03,.05,.04,.026,.05,.01,.003, HPM  572
     A.005,.005,.002,.0004,.0011,.0025,0.,0.,0.,0.,0.,.015,.008,.013,   HPM  573
     B.019,.039,.03,.056,.128,.021,.114,.557/                           HPM  574
      READ(5,1010) (RIV1(I),I=1,NYEAR)                                  HPM  575
      READ(5,1010) (RIV2(I),I=1,NYEAR)                                  HPM  576
      READ(5,1010) (RIV3(I),I=1,NYEAR)                                  HPM  577
 1010 FORMAT(15(F5.2))                                                  HPM  578
C                                                                       HPM  579
C **** CALCULATION OF POPULATION GREATER THAN 15 YEARS OLD              HPM  580
C                                                                       HPM  581
      DO 900 L=1,6                                                      HPM  582
      N1(L)=5*L                                                         HPM  583
      IF(L.EQ.1) GO TO 900                                              HPM  584
      MAI=(MP15(N1(L))-MP15(N1(L-1)))/5                                 HPM  585
      DO 901 I=1,4                                                      HPM  586
      J=N1(L-1)+I                                                       HPM  587
      MP15(J)=MAI+MP15(J-1)                                             HPM  588
      MP15(J-5)=MP15(J)                                                 HPM  589
  901 CONTINUE                                                          HPM  590
  900 CONTINUE                                                          HPM  591
C                                                                       HPM  592
C **** REVENUE CALCULATIONS                                             HPM  593
C                                                                       HPM  594
      DO 420 I=1,NYEAR                                                  HPM  595
      ITR1=0                                                            HPM  596
      ITR2=0                                                            HPM  597
      DO 4002 L=1,2                                                     HPM  598
      DO 4002 L2=1,15                                                   HPM  599
      IF(L.EQ.1) ITR1=ITR1+IFIX(FLOAT(IRESU(I))*PCTT(1,L2)*FLOAT(IRLP   HPM  600
     A(1,L2)))                                                          HPM  601
      IF(L.EQ.2) ITR2=ITR2+IFIX(FLOAT(IRECO(I))*PCTT(2,L2)*FLOAT(IRLP   HPM  602
     A(2,L2)))                                                          HPM  603
 4002 CONTINUE                                                          HPM  604
      IMORE=IFIX(FLOAT(IREMO(I))*RIV1(I))/1000                          HPM  605
      IAURE=IFIX(FLOAT(IREA(I))*RIV2(I))/1000                           HPM  606
      ITR1=ITR1/1000                                                    HPM  607
      ITR2=ITR2/1000                                                    HPM  608
      RLISC=.85*FLOAT(MP15(I))                                          HPM  609
      L1REV=IFIX(RIV3(I)*RLISC)/1000                                    HPM  610
      RX=FLOAT(ITGAS(I)*1000)                                           HPM  611
      IF(IVOL.EQ.2) GO TO 410                                           HPM  612
      IGREV=(IFIX(RX*RV1(I))-IFIX(.03*(RX*RV1(I))))/1000                HPM  613
      GO TO 411                                                         HPM  614
  410 IGREV=(IFIX(RX*TAX(I)-.03*RX*TAX(I)))/1000                        HPM  615
  411 I1TOT=ITR1+ITR2+IMORE+IAURE                                       HPM  616
      IADD=IFIX(AID(I)/(1.-AID(I))*FLOAT(IGREV+I1TOT))+L1REV            HPM  617
      ITREV(I)=IADD+IGREV+I1TOT                                         HPM  618
      NOY=1975+I                                                        HPM  619
      IF(I.GT.1) GO TO 40                                               HPM  620
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      WRITE(6,11)                                                       HPM  621
   11 FORMAT('1',1X,26('* '),'REVENUE PROJECTIONS 1/',1X,27('* '),/////,HPM  622
     A16X,96('-'),/,32X,'REGISTRATION',14X,'FUEL TAX',16X,'OTHER',16X,  HPM  623
     B'TOTAL',/,16X,'YEAR',14X,'REVENUES',16X,'REVENUES',14X,'REVENUES' HPM  624
     C,13X,'REVENUES',/,16X,96('-'),/)                                  HPM  625
   40 WRITE(6,12) NOY,I1TOT,IGREV,IADD,ITREV(I)                         HPM  626
   12 FORMAT(16X,I4,14X,I6,18X,I7,15X,I6,16X,I7,/)                      HPM  627
  420 CONTINUE                                                          HPM  628
      WRITE(6,13)                                                       HPM  629
   13 FORMAT(16X,96('-'))                                               HPM  630
      WRITE(6,14)                                                       HPM  631
   14 FORMAT(//,16X,'1/ IN THOUSANDS OF DOLLARS')                       HPM  632
      RETURN                                                            HPM  633
      END                                                               HPM  634
C                                                                       HPM  635
C                                                                       HPM  636
C                                                                       HPM  637
C                                                                       HPM  638
C                                                                       HPM  639
      SUBROUTINE PRESCD                                                 HPM  640
C *********************************************************************** HPM  641
C                                                                       HPM  642
C                                                                       HPM  643
C          THIS SUBROUTINE SIMULATES PRESENT PAVEMENT CONDITIONS        HPM  644
C          BY CREATING A NUMBER OF SAMPLE ROADWAY SECTIONS.             HPM  645
C                                                                       HPM  646
C                                                                       HPM  647
      DIMENSION MILE(3,6,6),VMM(3,2,6),VCR1(5,2,6),VCR2(5,2,6),         HPM  648
     1MAX(3,6),VCAN(6),HG2(3,6,105),HG3(3,5,105),                       HPM  649
     2HG4(3,5,105),HG5(3,6,105),HGWY(3,6,105),VCON(6),VCR3(5,2,6)       HPM  650
     3,WLON(3,6),ML1(3,6),HTO(3,6),GRATE1(16),GRATE2(16),ITREV(16)      HPM  651
     4,RINC(15),SINC(15),TOMG(15),BI(15),MIN(30),GPI(15),               HPM  652
     5MP15(30),ITGAS(15),IRECO(15),IRESU(15),IREMO(15),IREA(15),        HPM  653
     6RV1(15),RV2(15),AID(15),WSIN(16),TAX(15)                          HPM  654
      COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,               HPM  655
     1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IVOL,GRATE1,GRATE2,ITREVHPM  656
     2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN        HPM  657
      REAL MILE,MAX                                                     HPM  658
      XARK=1717127432147741315SB                                        HPM  659
      YARK=RANF(XARK)                                                   HPM  660
      IF(KSFLAG.EQ.2) GO TO 4017                                        HPM  661
C                                                                       HPM  662
C **** READING OF INITIAL DATA                                          HPM  663
C                                                                       HPM  664
C **** PAVEMENT CONDITIONS - PCT(RURAL)                                 HPM  665
      DATA(MILE(1,1,I),I=1,6)/79.,20.,1.,81.,18.,1./                    HPM  666
      DATA(MILE(1,2,I),I=1,6)/69.,30.,1.,67.,32.,1./                    HPM  667
      DATA(MILE(1,3,I),I=1,6)/61.,39.,0.,57.,43.,0./                    HPM  668
      DATA(MILE(1,4,I),I=1,6)/49.,47.,4.,49.,45.,6./                    HPM  669
      DATA(MILE(1,5,I),I=1,6)/27.,66.,7.,37.,58.,5./                    HPM  670
      DATA(MILE(1,6,I),I=1,6)/15.,70.,15.,20.,65.,15./                  HPM  671
C **** PAVEMENT CONDITIONS - PCT(URBAN)                                 HPM  672
      DATA(MILE(2,1,I),I=1,6)/89.,11.,0.,94.,6.,0./                     HPM  673
      DATA(MILE(2,2,I),I=1,6)/96.,4.,0.,92.,8.,0./                      HPM  674
      DATA(MILE(2,3,I),I=1,6)/51.,48.,1.,51.,48.,1./                    HPM  675
      DATA(MILE(2,4,I),I=1,6)/60.,40.,0.,57.,43.,0./                    HPM  676
      DATA(MILE(2,5,I),I=1,6)/53.,41.,6.,55.,39.,6./                    HPM  677
      DATA(MILE(2,6,I),I=1,6)/48.,40.,12.,52.,38.,10./                  HPM  678
C **** PAVEMENT CONDITIONS - PCT(SMALL URBAN)                           HPM  679
      DATA(MILE(3,1,I),I=1,6)/100.,0.,0.,100.,0.,0./                    HPM  680
      DATA(MILE(3,2,I),I=1,6)/92.,8.,0.,90.,10.,0./                     HPM  681
      DATA(MILE(3,3,I),I=1,6)/46.,54.,0.,46.,54.,0./                    HPM  682
      DATA(MILE(3,4,I),I=1,6)/45.,49.,6.,51.,45.,4./                    HPM  683
      DATA(MILE(3,5,I),I=1,6)/40.,51.,9.,46.,45.,9./                    HPM  684
      DATA(MILE(3,6,I),I=1,6)/35.,55.,10.,40.,50.,10./                  HPM  685
C                                                                       HPM  686
C **** READING OF ADT MEANS AND STANDARD DEVIATIONS                     HPM  687
C                                                                       HPM  688
      DATA((VMM(1,J,K),K=1,6),J=1,2)/16.4,5.7,5.2,1.2,.6,.2,6.65,3.5,   HPM  689
     A3.3,.6,.23,.09/                                                   HPM  690
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      DATA((VMM(2,J,K),K=1,6),J=1,2)/44.00,16.90,17.2,7.46,2.83,.76,16.,HPM  691
     A7.2,7.5,4.1,1.7,.4/                                                HPM  692
      DATA((VMM(3,J,K),K=1,6),J=1,2)/27.02,4.00,10.0,5.40,1.87,.560,10.8HPM  693
     A,1.8,5.1,3.0,1.,.25/                                               HPM  694
C                                                                        HPM  695
C **** READING OF V/C RATIOS                                             HPM  696
C                                                                        HPM  697
C **** PCT(RURAL)                                                        HPM  698
      DATA((VCR1(1,J,K),K=1,6),J=1,2)/0.,45.,55.,0.,63.,37.,100.,0.,     HPM  699
     A0.,100.,0.,0./                                                     HPM  700
      DATA((VCR1(2,J,K),K=1,6),J=1,2)/1.,28.,71.,3.,24.,73.,83.,17.,     HPM  701
     A0.,83.,17.,0./                                                     HPM  702
      DATA((VCR1(3,J,K),K=1,6),J=1,2)/1.,24.,75.,2.,40.,58.,64.,36.,     HPM  703
     A0.,68.,32.,0./                                                     HPM  704
      DATA((VCR1(4,J,K),K=1,6),J=1,2)/0.,2.,98.,0.,8.,92.,12.,58.,30.,   HPM  705
     A21.,59.,20./                                                       HPM  706
      DATA((VCR1(5,J,K),K=1,6),J=1,2)/0.,1.,99.,0.,3.,97.,2.,34.,64.,    HPM  707
     A6.,38.,56./                                                        HPM  708
C **** PCT(URBAN)                                                        HPM  709
      DATA((VCR2(1,J,K),K=1,6),J=1,2)/11.,67.,22.,22.,70.,8.,100.,0.,    HPM  710
     A0.,100.,0.,0./                                                     HPM  711
      DATA((VCR2(2,J,K),K=1,6),J=1,2)/4.,26.,70.,1.,49.,50.,92.,8.,0.,   HPM  712
     A88.,12.,0./                                                        HPM  713
      DATA((VCR2(3,J,K),K=1,6),J=1,2)/33.,41.,26.,50.,36.,14.,62.,31.,   HPM  714
     A7.,62.,32.,6./                                                     HPM  715
      DATA((VCR2(4,J,K),K=1,6),J=1,2)/21.,51.,28.,35.,45.,20.,42.,46.,   HPM  716
     A12.,42.,44.,14./                                                   HPM  717
      DATA((VCR2(5,J,K),K=1,6),J=1,2)/6.,26.,68.,10.,42.,48.,25.,56.,    HPM  718
     A19.,20.,67.,13./                                                   HPM  719
C **** PCT(SMALL URBAN)                                                  HPM  720
      DATA((VCR3(1,J,K),K=1,6),J=1,2)/0.,83.,17.,0.,91.,9.,100.,0.,0.,   HPM  721
     A100.,0.,0./                                                        HPM  722
      DATA((VCR3(2,J,K),K=1,6),J=1,2)/0.,22.,78.,0.,23.,77.,100.,0.,0.,  HPM  723
     A100.,0.,0./                                                        HPM  724
      DATA((VCR3(3,J,K),K=1,6),J=1,2)/8.,63.,29.,14.,67.,19.,67.,22.,    HPM  725
     A11.,66.,21.,13./                                                   HPM  726
      DATA((VCR3(4,J,K),K=1,6),J=1,2)/10.,42.,48.,11.,53.,36.,45.,40.,   HPM  727
     A15.,47.,42.,11./                                                   HPM  728
      DATA((VCR3(5,J,K),K=1,6),J=1,2)/0.,10.,90.,0.,15.,85.,36.,33.,31.,HPM  729
     A41.,35.,25./                                                       HPM  730
C                                                                        HPM  731
C **** READ TOTAL VMT                                                    HPM  732
C                                                                        HPM  733
      DATA(MAX(1,K),K=1,6)/11330.,4972.,13131.,8829.,2572.,7961./        HPM  734
      DATA(MAX(2,K),K=1,6)/7718.,946.,11182.,9500.,2794.,4057./          HPM  735
      DATA(MAX(3,K),K=1,6)/608.,173.,4284.,3291.,959.,1623./             HPM  736
C                                                                        HPM  737
C **** SIMULATION OF PRESENT HIGHWAY CONDITIONS                          HPM  738
C                                                                        HPM  739
 4017 DO 70 K=1,3                                                        HPM  740
      DO 70 N=1,6                                                        HPM  741
      WLON(K,N)=MAX(K,N)/(VMM(K,1,N)/1.2*100.)                           HPM  742
      IF(WLON(K,N).LT.2.) WLON(K,N)=2.                                   HPM  743
   70 HTO(K,N)=0.                                                        HPM  744
      HTOT=0.                                                            HPM  745
      DO 3000 I=1,3                                                      HPM  746
      DO 3000 J=1,6                                                      HPM  747
      ML=0                                                               HPM  748
      CONT=0.                                                            HPM  749
      IF(J.EQ.6) GO TO 5010                                              HPM  750
C                                                                        HPM  751
C **** ESTIMATION OF DAILY VOLUMES AND V/C RATIOS                        HPM  752
C                                                                        HPM  753
      DO 3002 I1=1,6                                                     HPM  754
      IF(I.EQ.1) VCAN(I1)=VCR1(J,1,I1)                                   HPM  755
      IF(I.EQ.2) VCAN(I1)=VCR2(J,1,I1)                                   HPM  756
 3002 IF(I.EQ.3) VCAN(I1)=VCR3(J,1,I1)                                   HPM  757
      IF(VCAN(1).NE.0.) GO TO 3007                                       HPM  758
      V1=0.                                                              HPM  759
      GO TO 3008                                                         HPM  760
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 3007 V1=(VCAN(4)/VCAN(1))                                                    HPM  761
 3008 V2=VCAN(5)/VCAN(2)                                                      HPM  762
      V3=VCAN(6)/VCAN(3)                                                      HPM  763
      V4=V1*VMM(I,1,J)                                                        HPM  764
      V5=V2*VMM(I,1,J)                                                        HPM  765
      V6=V3*VMM(I,1,J)                                                        HPM  766
      IF(V1.GT.1) V1=1/V1                                                     HPM  767
      IF(V2.GT.1) V2=1/V2                                                     HPM  768
      IF(V3.GT.1) V3=1/V3                                                     HPM  769
      S1=V1*VMM(I,2,J)                                                        HPM  770
      S2=V2*VMM(I,2,J)                                                        HPM  771
      S3=V3*VMM(I,2,J)                                                        HPM  772
 4000 ML=ML+1                                                                 HPM  773
      IF(I.EQ.1) A2=.8                                                        HPM  774
      IF(I.GT.1) A2=.9                                                        HPM  775
      H1=(.95-A2)*RANF(0)+A2                                                  HPM  776
      H2=(A2-.31)*RANF(0)+.31                                                 HPM  777
      H3=(.31-.2)*RANF(0)+.2                                                  HPM  778
      R3=RANF(0)                                                              HPM  779
      R3=R3*100.                                                              HPM  780
      IF(VCAN(6).GE.VCAN(5).AND.VCAN(5).GE.VCAN(4)) GO TO 3021                HPM  781
      IF(VCAN(5).GE.VCAN(6).AND.VCAN(6).GE.VCAN(4)) GO TO 3022                HPM  782
      IF(VCAN(4).GE.VCAN(5).AND.VCAN(5).GE.VCAN(6)) GO TO 3023                HPM  783
      IF(VCAN(5).GE.VCAN(4).AND.VCAN(4).GE.VCAN(6)) GO TO 3024                HPM  784
 3021 IF(R3.LE.VCAN(4)) GO TO 3040                                            HPM  785
      IF(R3.GT.VCAN(4).AND.R3.LE.(VCAN(5)+VCAN(4))) GO TO 3041                HPM  786
      GO TO 3042                                                              HPM  787
 3022 IF(R3.LE.VCAN(4)) GO TO 3040                                            HPM  788
      IF(R3.LE.(VCAN(6)+VCAN(4))) GO TO 3042                                  HPM  789
      GO TO 3041                                                              HPM  790
 3023 IF(R3.LE.VCAN(6)) GO TO 3042                                            HPM  791
      IF(R3.LE.(VCAN(6)+VCAN(5))) GO TO 3041                                  HPM  792
      GO TO 3040                                                              HPM  793
 3024 IF(R3.LE.VCAN(6)) GO TO 3042                                            HPM  794
      IF(R3.LE.(VCAN(6)+VCAN(4))) GO TO 3040                                  HPM  795
      GO TO 3041                                                              HPM  796
 5010 ML=ML+1                                                                 HPM  797
   80 HGWY(I,J,ML)=GAUSS(VMM(I,2,J),VMM(I,1,J))                               HPM  798
      NFLAG=1                                                                 HPM  799
      GO TO 3050                                                              HPM  800
 3040 HG3(I,J,ML)=H1                                                          HPM  801
   81 HGWY(I,J,ML)=GAUSS(S1,V4)                                               HPM  802
      NFLAG=2                                                                 HPM  803
      GO TO 3050                                                              HPM  804
 3041 HG3(I,J,ML)=H2                                                          HPM  805
   82 HGWY(I,J,ML)=GAUSS(S2,V5)                                               HPM  806
      NFLAG=3                                                                 HPM  807
      GO TO 3050                                                              HPM  808
 3042 HG3(I,J,ML)=H3                                                          HPM  809
   83 HGWY(I,J,ML)=GAUSS(S3,V6)                                               HPM  810
      NFLAG=4                                                                 HPM  811
C                                                                             HPM  812
C **** ASSIGNMENT OF PAVEMENT CONDITIONS                                      HPM  813
C                                                                             HPM  814
 3050 GO TO(1710,1712,1711) I                                                 HPM  815
 1710 IF(J.EQ.1.AND.HGWY(I,J,ML).LE.8.) GO TO 1713                            HPM  816
      IF(J.EQ.2.AND.HGWY(I,J,ML).LE.2.) GO TO 1713                            HPM  817
      IF(J.EQ.3.AND.HGWY(I,J,ML).LE.1.5) GO TO 1713                           HPM  818
      IF(J.EQ.4.AND.HGWY(I,J,ML).LE.0.6) GO TO 1713                           HPM  819
      IF(J.EQ.5.AND.HGWY(I,J,ML).LE.0.4) GO TO 1713                           HPM  820
      GO TO 1714                                                              HPM  821
 1711 IF(J.EQ.1.AND.HGWY(I,J,ML).LE.12.) GO TO 1713                           HPM  822
      IF(J.EQ.2.AND.HGWY(I,J,ML).LE.2.) GO TO 1713                            HPM  823
      IF(J.EQ.3.AND.HGWY(I,J,ML).LE.4.) GO TO 1713                            HPM  824
      IF(J.EQ.4.AND.HGWY(I,J,ML).LE.3.) GO TO 1713                            HPM  825
      IF(J.EQ.5.AND.HGWY(I,J,ML).LE.0.7) GO TO 1713                           HPM  826
      GO TO 1714                                                              HPM  827
 1712 IF(J.EQ.1.AND.HGWY(I,J,ML).LE.16.) GO TO 1713                           HPM  828
      IF(J.EQ.2.AND.HGWY(I,J,ML).LE.9.) GO TO 1713                            HPM  829
      IF(J.EQ.3.AND.HGWY(I,J,ML).LE.8.) GO TO 1713                            HPM  830
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      IF(J.EQ.4.AND.HGWY(I,J,ML).LE.3.) GO TO 1713                      HPM  831
      IF(J.EQ.5.AND.HGWY(I,J,ML).LE.1.) GO TO 1713                      HPM  832
      GO TO 1714                                                        HPM  833
 1713 GO TO(80,81,82,83) NFLAG                                          HPM  834
 1714 IF(HGWY(I,J,ML).LE.0.03) GO TO(80,81,82,83) NFLAG                 HPM  835
      DEVO=.75                                                          HPM  836
      IF(J.EQ.1) DEVO=1.3                                               HPM  837
      IF(J.GT.1.AND.J.LE.3) DEVO=1.05                                   HPM  838
      IF(I.EQ.1.AND.J.LE.2) GO TO 3051                                  HPM  839
      IF(I.GE.2.AND.J.LE.3) GO TO 3051                                  HPM  840
      A1=2.                                                             HPM  841
      B1=1.5                                                            HPM  842
      GO TO 3052                                                        HPM  843
 3051 A1=2.5                                                            HPM  844
      B1=2.                                                             HPM  845
      IF(I.EQ.1.AND.J.EQ.3) B1=1.8                                      HPM  846
 3052 R2=RANF(0)                                                        HPM  847
      R2=R2*100.                                                        HPM  848
      IF(R2.LE.MILE(I,J,3)) HG2(I,J,ML)=(A1-B1)*RANF(0)+B1              HPM  849
      IF(MILE(I,J,1).LE.MILE(I,J,2)) GO TO 3053                         HPM  850
      IF(R2.GT.MILE(I,J,3).AND.R2.LE.(MILE(I,J,3)+MILE(I,J,2))) HG2(    HPM  851
     AI,J,ML)=(3.4-A1)*RANF(0)+A1                                       HPM  852
      IF(R2.GT.(MILE(I,J,3)+MILE(I,J,2))) HG2(I,J,ML)=DEVO*RANF(0)+3.4  HPM  853
      GO TO 3060                                                        HPM  854
 3053 IF(R2.GT.MILE(I,J,3).AND.R2.LE.(MILE(I,J,3)+MILE(I,J,1))) HG2(    HPM  855
     AI,J,ML)=DEVO*RANF(0)+3.4                                          HPM  856
      IF(R2.GT.(MILE(I,J,3)+MILE(I,J,1))) HG2(I,J,ML)=(3.4-A1)*RANF(0)  HPM  857
     A+A1                                                               HPM  858
C                                                                       HPM  859
C **** LANE WIDTH ASSIGNMENT                                            HPM  860
C                                                                       HPM  861
 3060 IF(J.EQ.6) GO TO 3070                                             HPM  862
      DO 3061 I1=1,6                                                    HPM  863
      IF(I.EQ.1) VCON(I1)=VCR1(J,2,I1)                                  HPM  864
      IF(I.EQ.2) VCON(I1)=VCR2(J,2,I1)                                  HPM  865
 3061 IF(I.EQ.3) VCON(I1)=VCR3(J,2,I1)                                  HPM  866
      R4=RANF(0)                                                        HPM  867
      R4=R4*100.                                                        HPM  868
      IF(VCON(1).GE.VCON(2).AND.VCON(2).GE.VCON(3)) GO TO 3062          HPM  869
      IF(VCON(2).GE.VCON(1).AND.VCON(1).GE.VCON(3)) GO TO 3063          HPM  870
      IF(VCON(2).GE.VCON(3).AND.VCON(3).GE.VCON(1)) GO TO 3064          HPM  871
      IF(VCON(3).GE.VCON(2).AND.VCON(2).GE.VCON(1)) GO TO 3065          HPM  872
 3062 IF(R4.LT.VCON(3)) GO TO 3066                                      HPM  873
      IF(R4.LT.(VCON(3)+VCON(2))) GO TO 3067                            HPM  874
      GO TO 3068                                                        HPM  875
 3063 IF(R4.LT.VCON(3)) GO TO 3066                                      HPM  876
      IF(R4.LT.(VCON(3)+VCON(1))) GO TO 3068                            HPM  877
      GO TO 3067                                                        HPM  878
 3064 IF(R4.LT.VCON(1)) GO TO 3068                                      HPM  879
      IF(R4.LT.(VCON(3)+VCON(1))) GO TO 3066                            HPM  880
      GO TO 3067                                                        HPM  881
 3065 IF(R4.LT.VCON(1)) GO TO 3068                                      HPM  882
      IF(R4.LT.(VCON(1)+VCON(2))) GO TO 3067                            HPM  883
      GO TO 3066                                                        HPM  884
 3068 HG4(I,J,ML)=12.                                                   HPM  885
      GO TO 3070                                                        HPM  886
 3067 HG4(I,J,ML)=10.+RANF(0)                                           HPM  887
      GO TO 3070                                                        HPM  888
 3066 HG4(I,J,ML)=9.+RANF(0)                                            HPM  889
C                                                                       HPM  890
C **** ASSIGNMENT OF PAVEMENT TYPES                                     HPM  891
C                                                                       HPM  892
 3070 GO TO 3080                                                        HPM  893
C                                                                       HPM  894
C **** OPTIONAL OUTPUT STATEMENTS                                       HPM  895
C                                                                       HPM  896
 3081 DO 3082 ML=1,ML1(I,J)                                             HPM  897
      HGWY(I,J,ML)=CHANG*HGWY(I,J,ML)                                   HPM  898
      HTO(I,J)=HTO(I,J)+HGWY(I,J,ML)                                    HPM  899
      HTOT=HTOT+HGWY(I,J,ML)                                            HPM  900
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      GO TO 3082                                                                HPM  901
      IF(J.EQ.6) GO TO 6000                                                     HPM  902
      WRITE(6,1000) HGWY(I,J,ML),HG2(I,J,ML),HG3(I,J,ML),HG4(I,J,ML)            HPM  903
 1000 FORMAT(1X,F6.3,5X,F4.2,5X,F4.3,5X,F4.1,5X,F2.0)                           HPM  904
      GO TO 3082                                                                HPM  905
 6000 WRITE(6,1001) HGWY(I,J,ML),HG2(I,J,ML)                                    HPM  906
 1001 FORMAT(1X,F6.3,5X,F4.2,5X,F2.0)                                           HPM  907
 3082 CONTINUE                                                                  HPM  908
      GO TO 3000                                                                HPM  909
 3080 CONT=CONT+HGWY(I,J,ML)                                                    HPM  910
      CONT1=MAX(I,J)/WLON(I,J)                                                  HPM  911
      IF(J.EQ.6) GO TO 5000                                                     HPM  912
      IF(CONT.GE.CONT1) GO TO 3333                                              HPM  913
      GO TO 4000                                                                HPM  914
 5000 IF(CONT.GE.CONT1) GO TO 3333                                              HPM  915
      GO TO 5010                                                                HPM  916
 3333 ML1(I,J)=ML                                                               HPM  917
      CHANG=FLOAT(ML)/100.                                                      HPM  918
      IF(WLON(I,J).EQ.2.) CHANG=FLOAT(ML)/(MAX(I,J)/(2.*VMM(I,1,J)))            HPM  919
      GO TO 3081                                                                HPM  920
 3000 CONTINUE                                                                  HPM  921
      RETURN                                                                    HPM  922
      END                                                                       HPM  923
C                                                                               HPM  924
C                                                                               HPM  925
C                                                                               HPM  926
C                                                                               HPM  927
C                                                                               HPM  928
      SUBROUTINE PAVAGE                                                         HPM  929
C *************************************************************************** HPM  930
C                                                                               HPM  931
C                                                                               HPM  932
C          THIS SUBROUTINE AGES PAVEMENTS AND PERFORMES CAPITAL                 HPM  933
C          IMPROVEMENTS ON SELECT ROADWAY SECTIONS IF FUNDING                   HPM  934
C          LEVELS PERMIT.                                                       HPM  935
C                                                                               HPM  936
C                                                                               HPM  937
      DIMENSION SU(2,3,4),COM(2,3,5),EQUI(2,3),VVL1(3,2,6),HG6(3,6,105),HPM  938
     ASD(3,2,6),TYPE(2,3),HG5(3,6,105),HGWY(3,6,105),HG2(3,6,105),       HPM  939
     BML1(3,6),W(3),EQUIV(2,3,6),EQT1(3,3,6),EQT2(3,3,6),LANE(3,6,105),  HPM  940
     CPCON(5),PVAR(5),FUNDS(3,5),SMCI(3,5,105),COST1(3,5,105)            HPM  941
     D,COST2(3,5,105),DELCI(3,5,105),DELCON(3,5),CONST(3,5,8),           HPM  942
     EPEPC(3,5,4),PERC1(3,5,2),EQT(3,5,105),SMCON1(3,5)                  HPM  943
     F,HG3(3,5,105),HG4(3,5,105),SAX1(3,6),                              HPM  944
     GFUND(15),TFUND1(15),ADMIN(15),AID(15),                             HPM  945
     HSTRUC(3),GRATE1(16),GRATE2(16),ITREV(16),PEAK(3,5,105)             HPM  946
     I,RINC(15),SINC(15),TOMG(15),BI(15),MIN(30),GPI(15),                HPM  947
     JMP15(30),ITGAS(15),IRECO(15),IRESU(15),IREMO(15),IREA(15),         HPM  948
     KRV1(15),RV2(15),RELP(3,6),SM1(16,3,5),HK(3,6),WSIN(16),            HPM  949
     LHK1(3),SMCON9(3,5),IA1(2,3,5),IA2(2,3,5),IA3(2,3,5),IB1(2,3,5),    HPM  950
     MIB2(2,3,5),IB3(2,3,5),IC1(2,3,5),IC2(2,3,5),IC3(2,3,5),ID1(2,3,5) HPM  951
     N,ID2(2,3,5),ID3(2,3,5),IFAM(3,5),HUNT(3,5),EFORT(3,5)              HPM  952
      DIMENSION TM1(16,3,5),TM2(16,5),CONRT(3,5,8),KBEL(3,360),          HPM  953
     OKFAM(3,3,5),RPAD(15,3,5),CONI(2,3,5),PMIL(3,5),DRAPER(3,5),        HPM  954
     PERAPER(3,5),RELIN(3,5,105),SAX(3,5),FRAPER(3,5),TAX(15)            HPM  955
      COMMON RINC,SINC,TOMG,BI,MIN,GPI,NYEAR,SAT1,B9,TAX,                HPM  956
     1MP15,ITGAS,IRECO,IRESU,IREMO,IREA,RV1,RV2,IVOL,GRATE1,GRATE2,ITREVHPM  957
     2,HG5,HGWY,HG2,ML1,HG3,HG4,KCOW,KSSF,KSFLAG,KBARR,AID,WSIN          HPM  958
      IF(KSFLAG.EQ.2) GO TO 4017                                         HPM  959
C                                                                        HPM  960
C **** READING OF DATA                                                   HPM  961
C                                                                        HPM  962
C **** SYSTEM MILEAGES                                                   HPM  963
      DATA(SAX1(1,K),K=1,6)/827.,1048.,3032.,8724.,11332.,488859./      HPM  964
      DATA(SAX1(2,K),K=1,6)/210.,67.,781.,1526.,1183.,6415./            HPM  965
      DATA(SAX1(3,K),K=1,6)/27.,52.,512.,733.,614.,3460./               HPM  966
C **** SINGLE UNITS AND COMBINATION AVG. WEIGHTS AND AXLE PCTS.          HPM  967
      DATA(((SU(K,I,J),J=1,4),I=1,3),K=1,2)/5.5,2.,.42,.58,10.5,         HPM  968
     A4.,.44,.56,17.,7.,.38,.62,6.2,2.6,.31,.69,14.7,6.,.37,.63,         HPM  969
     B34.,14.,.28,.72/                                                   HPM  970
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      DATA(((COM(K,I,J),J=1,5),I=1,3),K=1,2)/22.,7.,.31,.37,.32,      HPM  971
     A25.,8.,.25,.25,.5,30.,4.,.26,.4,.34,30.,5.,.27,.4,.33,39.,     HPM  972
     B12.,.18,.34,.48,60.,14.,.15,.42,.43/                           HPM  973
C **** PCT. OF TRUCKS ON EACH HIGHWAY SYSTEM                          HPM  974
      DATA(((VVL1(I,J,K),K=1,6),J=1,2),I=1,3)/.147,.203,.203,.235,    HPM  975
     A.235,.021,.153,.097,.077,.045,.045,.009,.11,.14,.16,.23,.23,    HPM  976
     B.17,.09,.06,.04,.02,.02,.04,.11,.14,.16,.23,.23,.17,.09,.06,   HPM  977
     C.04,.02,.02,.04/                                               HPM  978
      DATA(((SD(I,J,K),K=1,6),J=1,2),I=1,3)/.03,.04,.04,.06,.06,     HPM  979
     A.005,.03,.02,.02,.02,.02,.005,.03,.04,.05,.06,.06,.05,.02,     HPM  980
     B.02,.01,.005,.005,.01,.03,.03,.04,.06,.06,.05,.02,.02,.01,     HPM  981
     C.005,.005,.01/                                                 HPM  982
C **** PCT OF TRUCK TYPES                                             HPM  983
      DATA((TYPE(J,K),K=1,3),J=1,2)/.77,.19,.04,.80,.15,.05/         HPM  984
C **** RELATIVE INCREASE IN HIGHWAY SYSTEM'S VMT                      HPM  985
      DATA((RELP(I,J),J=1,6),I=1,3)/.8,1.,.72,.64,.64,.64,1.32,2.16,  HPM  986
     A1.12,1.12,1.02,1.48,1.,1.24,1.,1.02,1.02,1.32/                 HPM  987
      DATA((SAX(I,J),J=1,5),I=1,3)/11330.,4972.,13131.,8829.,2572.,   HPM  988
     A7718.,946.,11182.,9500.,2794.,608.,173.,4284.,3291.,959./      HPM  989
      DATA((PMIL(I,J),J=1,5),I=1,3)/.003,.007,.0015,-.0002,-.0005,    HPM  990
     A.005,.033,.009,.005,.003,.013,.020,.012,.009,.0044/            HPM  991
      DO 749 I=1,3                                                    HPM  992
      DO 749 J=1,5                                                    HPM  993
      DRAPER(I,J)=SAX(I,J)                                            HPM  994
      ERAPER(I,J)=SAX1(I,J)                                           HPM  995
      FRAPER(I,J)=SAX(I,J)*VVL1(I,2,J)                                HPM  996
      DO 749 K=1,ML1(I,J)                                             HPM  997
      RELIN(I,J,K)=GAUSS(0.0,.015)                                    HPM  998
  749 CONTINUE                                                        HPM  999
      READ(5,502) ((EFORT(I,J),J=1,5),I=1,3)                          HPM 1000
  502 FORMAT(15(1X,F4.3))                                             HPM 1001
 4017 AAM=242780.                                                     HPM 1002
C                                                                     HPM 1003
C **** DETERMINATION OF TRAVEL TYPE                                   HPM 1004
C                                                                     HPM 1005
      DO 500 I=1,3                                                    HPM 1006
      DO 500 J=1,5                                                    HPM 1007
  500 HUNT(I,J)=0.                                                    HPM 1008
      MGFLAG=1                                                        HPM 1009
      MKN=0                                                           HPM 1010
      KCAR=1                                                          HPM 1011
      DO 850 I=1,3                                                    HPM 1012
      DO 850 J=1,5                                                    HPM 1013
  850 IFAM(I,J)=0                                                     HPM 1014
      DO 2912 NYEA=1,NYEAR+1                                          HPM 1015
      IF(NYEA.GE.2) KCAR=2                                            HPM 1016
      MKN=MKN+1                                                       HPM 1017
      MG1FLAG=1                                                       HPM 1018
      MRANK=1                                                         HPM 1019
      MFLAG=1                                                         HPM 1020
      IF(MGFLAG.EQ.2) GO TO 6754                                      HPM 1021
      MTOTAL=0                                                        HPM 1022
      DO 2046 K=1,2                                                   HPM 1023
      DO 2046 J=1,3                                                   HPM 1024
 2046 EQUI(K,J)=0.                                                    HPM 1025
      DO 8020 I=1,3                                                   HPM 1026
      DO 8020 J=1,3                                                   HPM 1027
      DO 8020 K=1,6                                                   HPM 1028
      EQT1(I,J,K)=0.                                                  HPM 1029
 8020 EQT2(I,J,K)=0.                                                  HPM 1030
      KOUNT=0                                                         HPM 1031
      GO TO 8001                                                      HPM 1032
 8988 DO 6000 I=1,3                                                   HPM 1033
      DO 6000 J=1,6                                                   HPM 1034
      MTOTAL=MTOTAL+ML1(I,J)                                          HPM 1035
C                                                                     HPM 1036
C **** SAMPLING TECHNIQUE TO DETERMINE AXLE LOADS                     HPM 1037
C                                                                     HPM 1038
      PCTS=VVL1(I,1,J)                                                HPM 1039
      PCTC=VVL1(I,2,J)                                                HPM 1040
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      PCCA=1-(PCTS+PCTC)                                                    HPM 1041
      DO 87 K=1,2                                                           HPM 1042
      EQUIV(K,I,J)=PCTC*EQUI(K,1)+PCTS*EQUI(K,2)+PCCA*EQUI(K,3)             HPM 1043
      IF(K.EQ.2) GO TO 86                                                   HPM 1044
      EQT1(1,I,J)=PCTC*EQUI(K,1)                                            HPM 1045
      EQT1(2,I,J)=PCTS*EQUI(K,2)                                            HPM 1046
      EQT1(3,I,J)=PCCA*EQUI(K,3)                                            HPM 1047
      GO TO 87                                                              HPM 1048
   86 EQT2(1,I,J)=PCTC*EQUI(K,1)                                            HPM 1049
      EQT2(2,I,J)=PCTS*EQUI(K,2)                                            HPM 1050
      EQT2(3,I,J)=PCCA*EQUI(K,3)                                            HPM 1051
   87 CONTINUE                                                              HPM 1052
 6000 CONTINUE                                                              HPM 1053
      GO TO 6754                                                            HPM 1054
 8001 WCARS=.8                                                              HPM 1055
      WCARM=3.3                                                             HPM 1056
      ICFLAG=1                                                              HPM 1057
      IFLAG=1                                                               HPM 1058
      X8=RANF(0)                                                            HPM 1059
      X9=RANF(0)                                                            HPM 1060
      KOUNT=KOUNT+1                                                         HPM 1061
      K1=1                                                                  HPM 1062
      IF(KOUNT.LE.1000.) GO TO 6006                                         HPM 1063
      IF(KOUNT.LE.2000.) GO TO 6007                                         HPM 1064
      IF(KOUNT.LE.3000.) GO TO 6008                                         HPM 1065
      GO TO 8988                                                            HPM 1066
 6006 IFFLAG=1                                                              HPM 1067
      IF(X9.LT.0.698) K1=2                                                  HPM 1068
      IF(X8.LE.TYPE(2,3)) GO TO 6010                                        HPM 1069
      IF(X8.LE.(TYPE(2,3)+TYPE(2,2))) GO TO 6011                            HPM 1070
      GO TO 6012                                                            HPM 1071
 6007 IFFLAG=2                                                              HPM 1072
      IF(X9.LT.0.506) K1=2                                                  HPM 1073
      IF(X8.LE.TYPE(1,3)) GO TO 6013                                        HPM 1074
      IF(X8.LE.(TYPE(1,3)+TYPE(1,2))) GO TO 6014                            HPM 1075
      GO TO 6015                                                            HPM 1076
C                                                                           HPM 1077
C **** COMBINATION WEIGHTS                                                  HPM 1078
C                                                                           HPM 1079
 6010 WATE=GAUSS(COM(K1,1,2),COM(K1,1,1))                                   HPM 1080
      IF(WATE.LT.2.5) GO TO 6010                                            HPM 1081
      DO 10 I2=1,3                                                          HPM 1082
   10 W(I2)=WATE*COM(K1,1,I2+2)                                             HPM 1083
      GO TO 7000                                                            HPM 1084
 6011 WATE=GAUSS(COM(K1,2,2),COM(K1,2,1))                                   HPM 1085
      IF(WATE.LT.2.5) GO TO 6011                                            HPM 1086
      DO 11 I2=1.3                                                          HPM 1087
   11 W(I2)=WATE*COM(K1,2,I2+2)                                             HPM 1088
      IFLAG=2                                                               HPM 1089
      GO TO 7000                                                            HPM 1090
 6012 WATE=GAUSS(COM(K1,3,2),COM(K1,3,1))                                   HPM 1091
      IF(WATE.LT.2.5) GO TO 6012                                            HPM 1092
      DO 12 I2=1,3                                                          HPM 1093
   12 W(I2)=WATE*COM(K1,3,I2+2)                                             HPM 1094
      IFLAG=3                                                               HPM 1095
      GO TO 7000                                                            HPM 1096
C                                                                           HPM 1097
C **** SINGLE UNIT TRUCK WEIGHT ESITMATES                                   HPM 1098
C                                                                           HPM 1099
 6013 WATE=GAUSS(SU(K1,3,2),SU(K1,3,1))                                     HPM 1100
      IF(WATE.LT.2.5) GO TO 6013                                            HPM 1101
      W(1)=WATE*SU(K1,3,3)                                                  HPM 1102
      W(2)=WATE*SU(K1,3,4)                                                  HPM 1103
      IFLAG=4                                                               HPM 1104
      GO TO 7000                                                            HPM 1105
 6014 WATE=GAUSS(SU(K1,2,2),SU(K1,2,1))                                     HPM 1106
      IF(WATE.LT.2.0) GO TO 6014                                            HPM 1107
      W(1)=WATE*SU(K1,2,3)                                                  HPM 1108
      W(2)=WATE*SU(K1,2,4)                                                  HPM 1109
      GO TO 7000                                                            HPM 1110
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 6015 WATE=GAUSS(SU(K1,1,2),SU(K1,1,1))                                  HPM 1111
      IF(WATE.LT.1.7) GO TO 6015                                         HPM 1112
      W(1)=WATE*SU(K1,1,3)                                               HPM 1113
      W(2)=WATE*SU(K1,1,4)                                               HPM 1114
      GO TO 7000                                                         HPM 1115
C                                                                        HPM 1116
C **** AUTO WEIGHT ESTIMATES                                             HPM 1117
C                                                                        HPM 1118
 6008 IFFLAG=3                                                           HPM 1119
      WATE=GAUSS(WCARS,WCARM)                                            HPM 1120
      IF(WATE.LT.1.2) GO TO 6008                                         HPM 1121
      W(1)=.6*WATE                                                       HPM 1122
      W(2)=.4*WATE                                                       HPM 1123
C                                                                        HPM 1124
C **** CALCULATION OF 18K AXLE LOADS                                     HPM 1125
C                                                                        HPM 1126
 7000 I7=2                                                               HPM 1127
      IF(IFFLAG.EQ.1) I7=3                                               HPM 1128
 9754 DO 7011 I2=1,I7                                                    HPM 1129
      IF(ICFLAG.EQ.1) GO TO 7020                                         HPM 1130
      IF(I2.EQ.2) GO TO 7012                                             HPM 1131
      IF(I2.EQ.3) GO TO 7016                                             HPM 1132
 7020 IF(I2.EQ.2) GO TO 7021                                             HPM 1133
      IF(I2.EQ.3) GO TO 7022                                             HPM 1134
 7013 EQ1=.0000062125*(W(I2))**4.16                                      HPM 1135
      GO TO 7015                                                         HPM 1136
 7012 GO TO(7013,7013,7014,7014) IFLAG                                   HPM 1137
 7016 GO TO(7013,7014,7014) IFLAG                                        HPM 1138
 7021 GO TO(7013,7013,7017,7017) IFLAG                                   HPM 1139
 7022 GO TO(7013,7017,7017) IFLAG                                        HPM 1140
 7014 EQ1=.00000047110*(W(I2))**4.155                                    HPM 1141
      GO TO 7015                                                         HPM 1142
 7017 EQ1=.00000090701*(W(I2))**4.115                                    HPM 1143
 7015 EQUI(ICFLAG,IFFLAG)=EQUI(ICFLAG,IFFLAG)+EQ1                        HPM 1144
 7011 CONTINUE                                                           HPM 1145
      IF(ICFLAG.EQ.2) GO TO 8001                                         HPM 1146
      ICFLAG=2                                                           HPM 1147
      GO TO 9754                                                         HPM 1148
C                                                                        HPM 1149
C **** CALCULATION OF PAVEMENT DETERIORATION                             HPM 1150
C                                                                        HPM 1151
 6754 HK2=0.                                                             HPM 1152
      DO 250 I=1,3                                                       HPM 1153
      HK1(I)=0.                                                          HPM 1154
      DO 290 J=1,5                                                       HPM 1155
      HK(I,J)=0.                                                         HPM 1156
      CHANG1=RELP(I,J)*GRATE1(NYEA)                                      HPM 1157
      IF(GRATE1(NYEA).LT.0.) CHANG1=(1./RELP(I,J))*GRATE1(NYEA)          HPM 1158
      CHANG2=RELP(I,J)*GRATE2(NYEA)                                      HPM 1159
      IF(GRATE2(NYEA).LT.0.) CHANG2=(1./RELP(I,J))*GRATE2(NYEA)          HPM 1160
      CHANG2=(((DRAPER(I,J)*(1.+CHANG2))/(ERAPER(I,J)*(1.+PMIL(I,J))))-  HPM 1161
     A(DRAPER(I,J)/ERAPER(I,J)))/(DRAPER(I,J)/ERAPER(I,J))               HPM 1162
      CHANG1=(((FRAPER(I,J)*(1.+CHANG1))/(ERAPER(I,J)*(1.+PMIL(I,J))))-  HPM 1163
     A(FRAPER(I,J)/ERAPER(I,J)))/(FRAPER(I,J)/ERAPER(I,J))               HPM 1164
      DRAPER(I,J)=DRAPER(I,J)*(1.+CHANG2)                                HPM 1165
      ERAPER(I,J)=ERAPER(I,J)*(1.+PMIL(I,J))                             HPM 1166
      FRAPER(I,J)=FRAPER(I,J)*(1.*CHANG1)                                HPM 1167
      IF(NYEA.EQ.16) GO TO 748                                           HPM 1168
  748 ICAN=2                                                             HPM 1169
      IF(J.EQ.1) ICAN=1                                                  HPM 1170
      EQUIV(ICAN,I,J)=EQUIV(ICAN,I,J)*((1.+CHANG1)/(1.+CHANG2))          HPM 1171
      DO 290 K=1,ML1(I,J)                                                HPM 1172
      IF(MGFLAG.EQ.2) GO TO 9117                                         HPM 1173
      EQT(I,J,K)=0.                                                      HPM 1174
      IF(I.EQ.1.AND.J.EQ.1) SAR=.183                                     HPM 1175
      IF(I.GT.1) SAR=.12                                                 HPM 1176
      IF(I.EQ.1.AND.J.GT.1) SAR=.16                                      HPM 1177
      MMFLAG=1                                                           HPM 1178
  379 IF(J.EQ.1) CAP=2.0                                                 HPM 1179
      IF(J.EQ.2) CAP=1.6                                                 HPM 1180
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      IF(J.EQ.3) CAP=1.4                                                HPM 1181
      IF(J.GT.3) CAP=1.                                                 HPM 1182
      IF(MMFLAG.GE.2) GO TO 1492                                        HPM 1183
      VAR11=((HGWY(I,J,K)*SAR)/CAP)+.8                                  HPM 1184
      LANE(I,J,K)=IFIX(VAR11)                                           HPM 1185
      IF(LANE(I,J,K).LT.1) LANE(I,J,K)=1                                HPM 1186
      IF(LANE(I,J,K).GT.5) LANE(I,J,K)=5                                HPM 1187
      IF(LANE(I,J,K).GE.2) GO TO 4793                                   HPM 1188
      IF(J.EQ.1) LANE(I,J,K)=2                                          HPM 1189
      IF(I.EQ.2.AND.J.EQ.2) LANE(I,J,K)=2                               HPM 1190
 4793 PEAK(I,J,K)=(HG3(I,J,K)*FLOAT(LANE(I,J,K))*CAP)/HGWY              HPM 1191
     A(I,J,K)                                                           HPM 1192
 4792 ICAN=2                                                            HPM 1193
      IF(J.EQ.1) ICAN=1                                                 HPM 1194
      IF(ICAN.EQ.1) GO TO 3820                                          HPM 1195
      VAR1=(VVL1(I,2,J)*HGWY(I,J,K)+.25*VVL1(I,1,J)*HGWY(I,J,K))*1000.  HPM 1196
      IF(VAR1.GE.100.) HG5(I,J,K)=4.15                                  HPM 1197
      IF(VAR1.GE.200.) HG5(I,J,K)=4.4                                   HPM 1198
      IF(VAR1.GE.300.) HG5(I,J,K)=4.9                                   HPM 1199
      IF(VAR1.GE.500.) HG5(I,J,K)=5.2                                   HPM 1200
      IF(VAR1.GE.750.) HG5(I,J,K)=5.5                                   HPM 1201
      IF(VAR1.GE.1200.) HG5(I,J,K)=6.                                   HPM 1202
      IF(VAR1.LT.100.0.AND.VAR1.GE.75.) HG5(I,J,K)=3.95                 HPM 1203
      IF(VAR1.LT.75.AND.VAR1.GE.50.) HG5(I,J,K)=3.7                     HPM 1204
      IF(VAR1.LT.50.) GO TO 3830                                        HPM 1205
      GO TO 3840                                                        HPM 1206
 3820 IF(J.EQ.1) HG5(I,J,K)=11.                                         HPM 1207
      GO TO 3840                                                        HPM 1208
 3830 IF(VAR1.GT.5.) HG5(I,J,K)=3.1                                     HPM 1209
      IF(VAR1.GT.15.) HG5(I,J,K)=3.25                                   HPM 1210
      IF(VAR1.GT.25.) HG5(I,J,K)=3.45                                   HPM 1211
      IF(VAR1.GT.35.) HG5(I,J,K)=3.6                                    HPM 1212
      IF(VAR1.LE.5.) HG5(I,J,K)=2.7                                     HPM 1213
 3840 IF(MRANK.EQ.2) GO TO 190                                          HPM 1214
 9117 ICAN=2                                                            HPM 1215
      IF(HG5(I,J,K).GT.9.) ICAN=1                                       HPM 1216
      REGAL=RELIN(I,J,K)                                                HPM 1217
      HGWY(I,J,K)=HGWY(I,J,K)*(1.+CHANG2+REGAL)                         HPM 1218
      HK(I,J)=HK(I,J)+HGWY(I,J,K)                                       HPM 1219
      HK1(I)=HK1(I)+HGWY(I,J,K)                                         HPM 1220
      HK2=HK2+HGWY(I,J,K)                                               HPM 1221
      EQT9=EQUIV(ICAN,I,J)*(HGWY(I,J,K))*365.                           HPM 1222
      IF(LANE(I,J,K).LT.2) YRV=2.                                       HPM 1223
      IF(LANE(I,J,K).GE.2) YRV=2.5                                      HPM 1224
      EQT(I,J,K)=EQT9/YRV+EQT(I,J,K)                                    HPM 1225
      IF(ICAN.EQ.1) GO TO 8111                                          HPM 1226
      BETA=.4+(.081*19.**3.23)/((HG5(I,J,K))**5.19)                     HPM 1227
      ROW=10.**5.93*(HG5(I,J,K))**9.36/19.**4.79                        HPM 1228
 8112 AF1=1.5                                                           HPM 1229
      IF(J.LE.3) AF1=2.0                                                HPM 1230
      IF(I.EQ.1.AND.J.EQ.3) AF1=1.8                                     HPM 1231
      IF(KCAR.EQ.2) GO TO 1301                                          HPM 1232
      HLM=4.6                                                           HPM 1233
      IF(J.EQ.1) HLM=4.8                                                HPM 1234
      IF(J.GT.3) HLM=4.2                                                HPM 1235
      EQT(I,J,K)=(EXP(ALOG(ROW)+(ALOG((HLM-HG2(I,J,K))/(HLM-AF1))/BETA  HPM 1236
     A)))+EQT(I,J,K)                                                    HPM 1237
      HG2(I,J,K)=HLM                                                    HPM 1238
 1301 HG6(I,J,K)=HG2(I,J,K)-(HG2(I,J,K)-AF1)*(EQT(I,J,K)/ROW)**BETA     HPM 1239
      GO TO 290                                                         HPM 1240
 8111 BETA=1.+3.63*(19.**5.2)/(HG5(I,J,K)**8.46)                        HPM 1241
      ROW=10.**5.85*(HG5(I,J,K)**7.35)/(19.**4.62)                      HPM 1242
      GO TO 8112                                                        HPM 1243
C                                                                       HPM 1244
C **** OPTIONAL OUTPUT STATEMENTS                                       HPM 1245
C                                                                       HPM 1246
 5999 IF(K.EQ.1) PRINT,I,J,ML1(I,J)                                     HPM 1247
      WRITE(6,100) HG6(I,J,K),HG2(I,J,K),HGWY(I,J,K),HG3(I,J,K),HG5(    HPM 1248
     AI,J,K),LANE(I,J,K),PEAK(I,J,K),EQUIV(ICAN,I,J),HG4(I,J,K)         HPM 1249
  100 FORMAT(10X,F4.2,5X,F4.2,5X,F6.2,5X,F5.3,5X,F5.2,5X,I2,5X,F4.2,    HPM 1250
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     A5X,F7.0,5X,F5.2)                                                  HPM 1251
  290 CONTINUE                                                          HPM 1252
      IF(MGFLAG.EQ.2) GO TO 1956                                        HPM 1253
      IF(KSFLAG.EQ.2) GO TO 1956                                        HPM 1254
C                                                                       HPM 1255
C **** READING OF INITIAL DATA                                          HPM 1256
C                                                                       HPM 1257
      DO 8016 N=1,16                                                    HPM 1258
      DO 8016 I=1,3                                                     HPM 1259
      DO 8016 J=1,5                                                     HPM 1260
      TM1(N,I,J)=0.                                                     HPM 1261
      IF(I.EQ.3) TM2(N,J)=0.                                            HPM 1262
      IF(N.EQ.16) GO TO 8016                                            HPM 1263
      RPAD(N,I,J)=0.                                                    HPM 1264
 8016 CONTINUE                                                          HPM 1265
      DO 8015 N=1,3                                                     HPM 1266
      DO 8015 I=1,3                                                     HPM 1267
      DO 8015 J=1,5                                                     HPM 1268
 8015 KFAM(N,I,J)=0                                                     HPM 1269
      DO 8017 J=1,3                                                     HPM 1270
      DO 8017 K=1,360                                                   HPM 1271
 8017 KBEL(J,K)=0                                                       HPM 1272
C                                                                       HPM 1273
C **** 1969 COST FOR IMPROVEMENTS                                       HPM 1274
C                                                                       HPM 1275
      DATA((CONRT(1,J,K),K=1,8),J=1,5)/363.,1722.,126.,631.,326.,173.,  HPM 1276
     A98.,127.,1042.,607.,153.,581.,177.,128.,87.,331.,664.,358.,91.,   HPM 1277
     B565.,145.,86.,41.,119.,283.,231.,54.,584.,120.,51.,22.,43.,161.,  HPM 1278
     C145.,35.,185.,89.,40.,18.,18./                                    HPM 1279
      DATA((CONRT(2,J,K),K=1,8),J=1,5)/8244.,3929.,5311.,2021.,1233.,   HPM 1280
     A658.,223.,6796.,5385.,3864.,758.,2826.,1305.,574.,207.,3721.,     HPM 1281
     B2387.,1452.,414.,1481.,740.,225.,139.,1355.,1095.,942.,231.,      HPM 1282
     C1004.,502.,128.,116.,665.,632.,587.,123.,705.,350.,115.,68.,319./ HPM 1283
      DATA((CONRT(3,J,K),K=1,8),J=1,5)/0.,0.,0.,764.,800.,273.,155.,    HPM 1284
     A337.,2442.,2016.,1087.,921.,877.,403.,172.,510.,1575.,987.,249.,  HPM 1285
     B905.,605.,149.,86.,645.,795.,598.,196.,619.,419.,138.,66.,349.,   HPM 1286
     C582.,472.,121.,506.,306.,107.,49.,296./                           HPM 1287
C **** PROBABILITY OF REPAIR TYPE                                       HPM 1288
      DATA(((PERC(I,J,K),K=1,4),J=1,5),I=1,3)/9.,2.,5.,84.,50.,12.,20., HPM 1289
     A18.,50.,15.,18.,17.,44.,18.,11.,27.,55.,16.,8.,21.,12.,0.,12.,    HPM 1290
     B76.,50.,4.,12.,34.,49.,5.,6.,40.,55.,4.,6.,35.,49.,3.,6.,42.,0.,  HPM 1291
     C0.,11.,89.,42.,7.,8.,43.,37.,5.,8.,50.,53.,6.,7.,34.,49.,3.,7.,   HPM 1292
     D41./                                                              HPM 1293
      DATA(((PERC1(I,J,K),K=1,2),J=1,5),I=1,3)/0.,100.,77.,23.,74.,26., HPM 1294
     A85.,15.,97.,3.,0.,100.,85.,15.,28.,72.,40.,60.,37.,63.,0.,100.,86.HPM 1295
     B,14.,40.,60.,44.,56.,37.,63./                                     HPM 1296
C                                                                       HPM 1297
      DATA(((CONI(I,J,K),K=1,4),J=1,3),I=1,2)/30.,40.,20.,10.,40.,30.,  HPM 1298
     A20.,10.,50.,20.,20.,10.,30.,40.,20.,10.,35.,30.,25.,10.,40.,20.,  HPM 1299
     B30.,10./                                                          HPM 1300
C                                                                       HPM 1301
C                                                                       HPM 1302
C **** DETERMINATION OF INITIAL INDEXES                                 HPM 1303
C                                                                       HPM 1304
 1956 DO 1955 I=1,3                                                     HPM 1305
      DO 1955 J=1,5                                                     HPM 1306
      DO 1955 K=1,8                                                     HPM 1307
      IF(MGFLAG.EQ.1) CONST(I,J,K)=1.57*CONRT(I,J,K)                    HPM 1308
      IF(MGFLAG.NE.1) CONST(I,J,K)=CONST(I,J,K)*(1.+WSIN(NYEA)/100.)    HPM 1309
 1955 CONTINUE                                                          HPM 1310
      MFLAG=1                                                           HPM 1311
      TFUND=FLOAT(ITREV(NYEA))                                          HPM 1312
      DO 2000 I=1,3                                                     HPM 1313
      DO 2000 J=1,5                                                     HPM 1314
      SMCON1(I,J)=0.                                                    HPM 1315
  370 IF(I.NE.1) GO TO 1200                                             HPM 1316
      I1=2                                                              HPM 1317
      IF(J.LE.2) I2=1                                                   HPM 1318
      IF(J.EQ.3) I2=2                                                   HPM 1319
      IF(J.GT.3) I2=3                                                   HPM 1320
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      GO TO 1201                                                        HPM 1321
 1200 I1=1                                                              HPM 1322
      IF(J.LE.3) I2=1                                                   HPM 1323
      IF(J.EQ.4) I2=2                                                   HPM 1324
      IF(J.EQ.5) I2=3                                                   HPM 1325
 1201 IF(MG1FLAG.EQ.2) GO TO 9001                                       HPM 1326
      IF(MFLAG.EQ.2) GO TO 973                                          HPM 1327
      DO 2000 K=1,ML1(I,J)                                              HPM 1328
  973 MMFLAG=2                                                          HPM 1329
      GO TO 379                                                         HPM 1330
 1492 I22F=1                                                            HPM 1331
      IF(HG4(I,J,K).EQ.12.) GO TO 1493                                  HPM 1332
      I22F=2                                                            HPM 1333
      IF(LANE(I,J,K).EQ.1) PTY1=1.-.24*((12.-HG4(I,J,K))/3.)            HPM 1334
      IF(LANE(I,J,K).NE.1) PTY1=1.-.18*((12.-HG4(I,J,K))/3.)            HPM 1335
 1493 DELCIC=(HGWY(I,J,K)*PEAK(I,J,K))/((FLOAT(LANE(I,J,K))+1)*CAP)     HPM 1336
      IF(DELCIC.GT.1.) DELCIC=1.                                        HPM 1337
      PLIE=3.6                                                          HPM 1338
      IF(J.EQ.1) PLIE=3.8                                               HPM 1339
      IF(J.GT.3) PLIE=3.2                                               HPM 1340
      HG3(I,J,K)=(HGWY(I,J,K)*PEAK(I,J,K))/(FLOAT(LANE(I,J,K))*CAP)     HPM 1341
      CONI(I1,I2,5)=(1.-DELCIC)*(CONI(I1,I2,2)/.6)                      HPM 1342
      IF(DELCIC.LT.0.4) CONI(I1,I2,5)=CONI(I1,I2,2)                     HPM 1343
      PCON(1)=(HG6(I,J,K)-1.)*(CONI(I1,I2,1)/PLIE)                      HPM 1344
      IF(PCON(1).LT.0.) PCON(1)=0.                                      HPM 1345
      HELP=HG3(I,J,K)                                                   HPM 1346
      IF(HG3(I,J,K).GT.1.) HG3(I,J,K)=1.                                HPM 1347
      PCON(2)=(1.-HG3(I,J,K))*(CONI(I1,I2,2)/.6)                        HPM 1348
      IF(HG3(I,J,K).LT.0.4) PCON(2)=CONI(I1,I2,2)                       HPM 1349
      PCON(3)=(HG4(I,J,K)-9.)*(CONI(I1,I2,3)/3.)                        HPM 1350
      PARA=HG5(I,J,K)                                                   HPM 1351
      IF(PARA.EQ.11.) PARA=7.                                           HPM 1352
      PCON(5)=(PARA-2.6)*CONI(I1,I2,4)/4.4                              HPM 1353
      PCON(4)=PCON(2)                                                   HPM 1354
      IF(LANE(I,J,K).EQ.5) PCON(2)=CONI(I1,I2,2)                        HPM 1355
      IF(MFLAG.EQ.2) GO TO 371                                          HPM 1356
      SMCI(I,J,K)=PCON(1)+PCON(2)+PCON(3)+PCON(5)                       HPM 1357
      SMCON1(I,J)=SMCON1(I,J)+(PCON(1)+PCON(3)+PCON(4)+PCON(5))*HGWY    HPM 1358
     1(I,J,K)                                                           HPM 1359
      IF(NYEA.EQ.(NYEAR+1)) GO TO 2000                                  HPM 1360
C                                                                       HPM 1361
C **** DETERMINATION OF IMPROVEMENT TYPE                                HPM 1362
C                                                                       HPM 1363
      X70=RANF(0)*100.                                                  HPM 1364
      IF(PERC(I,J,4).GT.PERC(I,J,1).AND.PERC(I,J,1).GE.PERC(I,J,3))     HPM 1365
     AGO TO 2010                                                        HPM 1366
      IF(PERC(I,J,1).GT.PERC(I,J,3).AND.PERC(I,J,3).GT.PERC(I,J,4))     HPM 1367
     AGO TO 2011                                                        HPM 1368
      IF(PERC(I,J,1).GT.PERC(I,J,4).AND.PERC(I,J,2).GT.PERC(I,J,3))     HPM 1369
     AGO TO 2012                                                        HPM 1370
      IF(PERC(I,J,4).GT.PERC(I,J,1)) GO TO 2013                         HPM 1371
      GO TO 2014                                                        HPM 1372
C                                                                       HPM 1373
 2010 IF(X70.LE.PERC(I,J,2)) GO TO 2020                                 HPM 1374
      IF(X70.LE.(PERC(I,J,2)+PERC(I,J,3))) GO TO 2021                   HPM 1375
      IF(X70.LE.(PERC(I,J,2)+PERC(I,J,3)+PERC(I,J,1))) GO TO 2022       HPM 1376
      GO TO 2023                                                        HPM 1377
 2011 IF(X70.LE.PERC(I,J,2)) GO TO 2020                                 HPM 1378
      IF(X70.LE.(PERC(I,J,2)+PERC(I,J,4))) GO TO 2023                   HPM 1379
      IF(X70.LE.(PERC(I,J,2)+PERC(I,J,4)+PERC(I,J,3))) GO TO 2021       HPM 1380
      GO TO 2020                                                        HPM 1381
 2012 IF(X70.LE.PERC(I,J,3)) GO TO 2021                                 HPM 1382
      IF(X70.LE.(PERC(I,J,3)+PERC(I,J,2))) GO TO 2020                   HPM 1383
      IF(X70.LE.(PERC(I,J,3)+PERC(I,J,2)+PERC(I,J,4))) GO TO 2023       HPM 1384
      GO TO 2022                                                        HPM 1385
 2013 IF(X70.LE.PERC(I,J,3)) GO TO 2021                                 HPM 1386
      GO TO 2023                                                        HPM 1387
 2014 IF(X70.LE.PERC(I,J,2)) GO TO 2020                                 HPM 1388
      IF(X70.LE.(PERC(I,J,2)+PERC(I,J,3))) GO TO 2021                   HPM 1389
      IF(X70.LE.(PERC(I,J,2)+PERC(I,J,3)+PERC(I,J,4))) GO TO 2023       HPM 1390
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      GO TO 2022                                                        HPM 1391
 2020 COST1(I,J,K)=CONST(I,J,3)                                         HPM 1392
      GO TO 2030                                                        HPM 1393
 2021 COST1(I,J,K)=CONST(I,J,6)                                         HPM 1394
      GO TO 2030                                                        HPM 1395
 2022 COST1(I,J,K)=CONST(I,J,2)                                         HPM 1396
      GO TO 2030                                                        HPM 1397
 2023 COST1(I,J,K)=CONST(I,J,7)                                         HPM 1398
C                                                                       HPM 1399
C **** DETERMINATION OF WIDENING COSTS                                  HPM 1400
C                                                                       HPM 1401
 2030 X71=RANF(0)*100.                                                  HPM 1402
      IF(PERC1(I,J,2).GE.PERC1(I,J,1)) GO TO 2031                       HPM 1403
      GO TO 2032                                                        HPM 1404
 2031 IF(X71.LE.PERC1(I,J,1)) COST2(I,J,K)=CONST(I,J,1)                 HPM 1405
      IF(X71.GT.PERC1(I,J,1)) COST2(I,J,K)=CONST(I,J,4)                 HPM 1406
      GO TO 371                                                         HPM 1407
 2032 IF(X71.LE.PERC1(I,J,2)) COST2(I,J,K)=CONST(I,J,4)                 HPM 1408
      IF(X71.GT.PERC1(I,J,2)) COST2(I,J,K)=CONST(I,J,1)                 HPM 1409
C                                                                       HPM 1410
C **** DETERMINATION OF COST-EFFECTIVENESS OF IMPOVEMENTS               HPM 1411
C                                                                       HPM 1412
  371 PARK=4.6                                                          HPM 1413
      IF(J.EQ.1) PARK=4.8                                               HPM 1414
      IF(J.GT.3) PARK=4.2                                               HPM 1415
      REV=(PARK-1.)*(CONI(I1,I2,1)/PLIE)                                HPM 1416
      IF(I22F.EQ.2) DART=(1.-HG3(I,J,K)*PTY1)*(CONI(I1,I2,2)/.6)        HPM 1417
      IF(I22F.EQ.2.AND.(HG3(I,J,K)*PTY1).LT.0.4) DART=CONI(I1,I2,2)     HPM 1418
      PVAR(1)=((REV-PCON(1))*HGWY(I,J,K)*RELP(I,J))/COST1               HPM 1419
     A(I,J,K)                                                           HPM 1420
      PVAR(2)=((CONI(I1,I2,5)-PCON(2)+REV-PCON(1)+CONI(I1,I2,3          HPM 1421
     A)-PCON(3))*HGWY(I,J,K)*RELP(I,J))/COST2(I,J,K)                    HPM 1422
      PVAR(3)=((CONI(I1,I2,3)-PCON(3)+REV-PCON(1))*HGWY(I,J,K)*RELP     HPM 1423
     A(I,J))/CONST(I,J,5)                                               HPM 1424
      IF(I22F.EQ.2) PVAR(3)=((CONI(I1,I2,3)-PCON(3)+REV-PCON(1)-PCON    HPM 1425
     A(2)+DART)*HGWY(I,J,K)*RELP(I,J))/CONST(I,J,5)                     HPM 1426
      PVAR(4)=PVAR(2)                                                   HPM 1427
      IF(LANE(I,J,K).EQ.5) PVAR(2)=0.                                   HPM 1428
      IF(MFLAG.EQ.2) GO TO 372                                          HPM 1429
      DELCI(I,J,K)=PVAR(1)+PVAR(2)+PVAR(3)                              HPM 1430
 2000 CONTINUE                                                          HPM 1431
      IF(NYEA.EQ.(NYEAR+1)) GO TO 710                                   HPM 1432
C                                                                       HPM 1433
C **** DETERMINATION OF MAINTAINANCE                                    HPM 1434
C                                                                       HPM 1435
      AAM=AAM*(1.+WSIN(NYEA)/400.)                                      HPM 1436
      TFUND2=((TFUND-AAM)*.67)/1.03                                     HPM 1437
      FUND(NYEA)=AAM                                                    HPM 1438
      TFUND1(NYEA)=.33*(TFUND-AAM)                                      HPM 1439
      ADMIN(NYEA)=TFUND2*1.03                                           HPM 1440
      GO TO 2950                                                        HPM 1441
 7281 MFLAG=2                                                           HPM 1442
      DO 90 I=1,3                                                       HPM 1443
      DO 90 J=1,5                                                       HPM 1444
      K11=0                                                             HPM 1445
      TCOST=0.                                                          HPM 1446
      FUNDS(I,J)=EFORT(I,J)*TFUND2+HUNT(I,J)                            HPM 1447
      IFAM(I,J)=IFAM(I,J)+IFIX(FUNDS(I,J)-HUNT(I,J))                    HPM 1448
      IKONT=0                                                           HPM 1449
      JFLAG=1                                                           HPM 1450
      DO 1654 K=1,ML1(I,J)                                              HPM 1451
      PMIN=1.2                                                          HPM 1452
      IF(J.LE.3) PMIN=1.5                                               HPM 1453
      IF(I.EQ.1.AND.J.EQ.3.AND.HGWY(I,J,K).LT.6.) PMIN=1.3              HPM 1454
      IF(HG6(I,J,K).GT.PMIN) GO TO 1654                                 HPM 1455
      ICAN=2                                                            HPM 1456
      IF(HG5(I,J,K).GT.9.) ICAN=1                                       HPM 1457
      IF(ICAN.EQ.1) GO TO 6100                                          HPM 1458
      BETA=.4+(.081*19.**3.23)/((HG5(I,J,K))*5.19)                      HPM 1459
      ROW=10.**5.93*(HG5(I,J,K))**9.36/19.**4.79                        HPM 1460
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 6101 AF1=1.5                                                                  HPM 1461
      IF(J.LE.3) AF1=2.                                                        HPM 1462
      IF(I.EQ.1.AND.J.EQ.3) AF1=1.8                                            HPM 1463
      HLM=4.6                                                                  HPM 1464
      IF(J.EQ.1) HLM=4.8                                                       HPM 1465
      IF(J.GT.3) HLM=4.2                                                       HPM 1466
      PFLY=2.2                                                                 HPM 1467
      IF(J.LE.3) PFLY=2.6                                                      HPM 1468
      IF(I.EQ.1.AND.J.EQ.3.AND.HGWY(I,J,K).LT.6.) PFLY=2.5                     HPM 1469
      EQT(I,J,K)=EXP(ALOG(ROW)+(ALOG((HLM-PFLY)/(HLM-AF1))/BETA))              HPM 1470
      COSTA=CONST(I,J,7)*ERAPER(I,J)/FLOAT(ML1(I,J))                           HPM 1471
      TCOST=.1*COSTA+TCOST                                                     HPM 1472
      IF(J.LE.3) TCOST=.15*COSTA+TCOST                                         HPM 1473
      IF(I.EQ.1.AND.J.EQ.3.AND.HGWY(I,J,K).LT.6.) TCOST=.1*COSTA               HPM 1474
     A+TCOST                                                                   HPM 1475
      IF(TCOST.GT.FUNDS(I,J)) GO TO 381                                        HPM 1476
      PLIE=3.6                                                                 HPM 1477
      IF(J.EQ.1) PLIE=3.8                                                      HPM 1478
      IF(J.GT.3) PLIE=3.2                                                      HPM 1479
      MG1FLAG=2                                                                HPM 1480
      GO TO 370                                                                HPM 1481
 9001 PCON(1)=(HG6(I,J,K)-1.)*(CONI(I1,I2,1)/PLIE)                             HPM 1482
      IF(PCON(1).LT.0) PCON(1)=0.                                              HPM 1483
      REV=(PFLY-1.)*(CONI(I1,I2,1)/PLIE)                                       HPM 1484
      SMCI(I,J,K)=SMCI(I,J,K)-PCON(1)+REV                                      HPM 1485
      REV1=CONI(I1,I2,1)                                                       HPM 1486
      DELCI(I,J,K)=DELCI(I,J,K)-(((REV1-PCON(1))*HGWY(I,J,K)*                  HPM 1487
     ARELP(I,J))/COST1(I,J,K))+(((REV1-REV)*HGWY(I,J,K)*RELP                   HPM 1488
     B(I,J))/COST1(I,J,K))                                                     HPM 1489
      HG6(I,J,K)=PFLY                                                          HPM 1490
      GO TO 1654                                                               HPM 1491
 6100 BETA=1.+3.63*(19.**5.2)/(HG5(I,J,K)**8.46)                               HPM 1492
      ROW=10.**5.85*(HG5(I,J,K)**7.35)/(19.**4.62)                             HPM 1493
      GO TO 6101                                                               HPM 1494
 1654 CONTINUE                                                                 HPM 1495
      DELCON(I,J)=0.                                                           HPM 1496
      SMCON9(I,J)=0.                                                           HPM 1497
      DO 2003 K=1,ML1(I,J)                                                     HPM 1498
      SMCON9(I,J)=SMCON9(I,J)+SMCI(I,J,K)                                      HPM 1499
 2003 DELCON(I,J)=DELCON(I,J)+DELCI(I,J,K)                                     HPM 1500
  352 X91=RANF(0)*FLOAT(ML1(I,J))-.01                                          HPM 1501
      MG1FLAG=1                                                                HPM 1502
      IKONT=IKONT+1                                                            HPM 1503
      IF(IKONT.GT.500) GO TO 700                                               HPM 1504
      K=IFIX(X91)+1                                                            HPM 1505
      IF(JFLAG.EQ.2) GO TO 350                                                 HPM 1506
      IF(DELCI(I,J,K).GT.(DELCON(I,J)/FLOAT(ML1(I,J)))) GO TO 351              HPM 1507
      GO TO 352                                                                HPM 1508
  351 JFLAG=2                                                                  HPM 1509
      GO TO 370                                                                HPM 1510
C                                                                              HPM 1511
C **** DETERMINING PRIORITIZATION ON THE BASIS OF COST-BENEFIT                 HPM 1512
C                                                                              HPM 1513
  372 TOP=0.                                                                   HPM 1514
      DO 373 N2=1,3                                                            HPM 1515
      IF(PVAR(N2).LT.TOP) GO TO 373                                            HPM 1516
      TOP=PVAR(N2)                                                             HPM 1517
      IR1=N2                                                                   HPM 1518
  373 CONTINUE                                                                 HPM 1519
      IF(HELP.GE.1.2.AND.LANE(I,J,K).LT.5) IR1=2                               HPM 1520
      IF(IR1.EQ.1) COSTA=COST1(I,J,K)*ERAPER(I,J)/FLOAT(ML1(I,J))              HPM 1521
      IF(IR1.EQ.2) COSTA=COST2(I,J,K)*ERAPER(I,J)/FLOAT(ML1(I,J))              HPM 1522
      IF(IR1.EQ.3) COSTA=CONST(I,J,5)*ERAPER(I,J)/FLOAT(ML1(I,J))              HPM 1523
      TCOST=TCOST+COSTA                                                        HPM 1524
      IF(TCOST.GT.FUNDS(I,J)) GO TO 381                                        HPM 1525
      GO TO 380                                                                HPM 1526
  350 IF(SMCI(I,J,K).LT.(SMCON9(I,J)/FLOAT(ML1(I,J)))) GO TO 450               HPM 1527
      GO TO 352                                                                HPM 1528
  450 JFLAG=1                                                                  HPM 1529
      GO TO 370                                                                HPM 1530
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C                                                                       HPM 1531
C **** REVISION OF INDEXES AFTER MAINTENANCE                            HPM 1532
C                                                                       HPM 1533
  380 IF(IR1.EQ.2) GO TO 383                                            HPM 1534
 1818 IF(IR1.NE.2) DELCI(I,J,K)=DELCI(I,J,K)-PVAR(IR1)                  HPM 1535
      IF(IR1.EQ.2) DELCI(I,J,K)=DELCI(I,J,K)-PVAR(1)-PVAR(3)            HPM 1536
      IF(IR1.EQ.1) SMCI(I,J,K)=SMCI(I,J,K)-PCON(1)+REV                  HPM 1537
      IF(IR1.EQ.3) SMCI(I,J,K)=SMCI(I,J,K)-PCON(1)-PCON(3)+CONI(I1,I2,  HPM 1538
     A3)+REV                                                            HPM 1539
      IF(IR1.EQ.3.AND.I22F.EQ.2) SMCI(I,J,K)=SMCI(I,J,K)-PCON(2)+DART   HPM 1540
      IF(IR1.EQ.2) SMCI(I,J,K)=SMCI(I,J,K)-PCON(1)+REV-                 HPM 1541
     APCON(3)+CONI(I1,I2,3)-PCON(2)+CONI(I1,I2,5)                       HPM 1542
      GO TO 1819                                                        HPM 1543
  383 LANE(I,J,K)=LANE(I,J,K)+1                                         HPM 1544
      D1=(HGWY(I,J,K)*PEAK(I,J,K))/((LANE(I,J,K)+1)*CAP)                HPM 1545
      IF(D1.GT.1.) D1=1.                                                HPM 1546
      D2=(1.-D1)*(CONI(I1,I2,2)/.6)                                     HPM 1547
      IF(D1.LT.0.4) D2=CONI(I1,I2,2)                                    HPM 1548
      DELCI(I,J,K)=DELCI(I,J,K)-PVAR(2)+(((D2-CONI(I1,I2,5))*HGWY(I,    HPM 1549
     AJ,K)*RELP(I,J))/COST2(I,J,K))                                     HPM 1550
      GO TO 1818                                                        HPM 1551
 1819 MRANK=2                                                           HPM 1552
      GO TO 4792                                                        HPM 1553
  190 PARA=HG5(I,J,K)                                                   HPM 1554
      IF(PARA.EQ.11.) PARA=7.                                           HPM 1555
      SMCI(I,J,K)=SMCI(I,J,K)-PCON(5)+((PARA-2.6)*CONI(I1,I2,4)/4.4)    HPM 1556
      EQT(I,J,K)=0.                                                     HPM 1557
      IF(I22F.EQ.2) HG3(I,J,K)=PTY1*HG3(I,J,K)                          HPM 1558
      IF(I22F.EQ.2) PEAK(I,J,K)=PTY1*PEAK(I,J,K)                        HPM 1559
      IF(IR1.EQ.2) HG3(I,J,K)=DELCIC                                    HPM 1560
      IF(IR1.GE.2) HG4(I,J,K)=12.                                       HPM 1561
      HG6(I,J,K)=4.6                                                    HPM 1562
      IF(J.EQ.1) HG6(I,J,K)=4.8                                         HPM 1563
      IF(J.GT.3) HG6(I,J,K)=4.2                                         HPM 1564
      DELCON(I,J)=0.                                                    HPM 1565
      SMCON9(I,J)=0.                                                    HPM 1566
      DO 2002 MKE=1,ML1(I,J)                                            HPM 1567
      SMCON9(I,J)=SMCON9(I,J)+SMCI(I,J,MKE)                             HPM 1568
 2002 DELCON(I,J)=DELCON(I,J)+DELCI(I,J,MKE)                            HPM 1569
      GO TO 352                                                         HPM 1570
  381 HUNT(I,J)=FUNDS(I,J)-(TCOST-COSTA)                                HPM 1571
      DO 9973 K=1,ML1(I,J)                                              HPM 1572
      IF(J.LE.3) RINTO=2.6                                              HPM 1573
      IF(I.EQ.1.AND.J.EQ.3.AND.HGWY(I,J,K).LT.6.) RINTO=2.1             HPM 1574
      IF(J.GT.3) RINTO=2.1                                              HPM 1575
      IF(HG6(I,J,K).LE.RINTO) K11=K11+1                                 HPM 1576
 9973 CONTINUE                                                          HPM 1577
      RPAD(NYEA,I,J)=FLOAT(K11)/FLOAT(ML1(I,J))+RPAD(NYEA,I,J)          HPM 1578
   90 CONTINUE                                                          HPM 1579
      IF(MKN.NE.0) GO TO 70                                             HPM 1580
      NOY=1974+NYEA+1                                                   HPM 1581
      N=1                                                               HPM 1582
 1985 IF(NOY.EQ.1980) KFK=1                                             HPM 1583
      IF(NOY.EQ.1985) KFK=2                                             HPM 1584
      IF(NOY.EQ.1990) KFK=3                                             HPM 1585
      DO 1984 I=1,3                                                     HPM 1586
      DO 1984 J=1,5                                                     HPM 1587
      IA1(N,I,J)=0                                                      HPM 1588
      IA2(N,I,J)=0                                                      HPM 1589
      IA3(N,I,J)=0                                                      HPM 1590
      IB1(N,I,J)=0                                                      HPM 1591
      IB2(N,I,J)=0                                                      HPM 1592
      IB3(N,I,J)=0                                                      HPM 1593
      IC1(N,I,J)=0                                                      HPM 1594
      IC2(N,I,J)=0                                                      HPM 1595
      IC3(N,I,J)=0                                                      HPM 1596
      ID1(N,I,J)=0                                                      HPM 1597
      ID2(N,I,J)=0                                                      HPM 1598
      ID3(N,I,J)=0                                                      HPM 1599
      DO 1984 K=1,ML1(I,J)                                              HPM 1600
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      N1=1                                                              HPM 1601
      IF(N.EQ.2) N1=IFIX(HGWY(I,J,K)*1000.)                             HPM 1602
C                                                                       HPM 1603
C **** PERC. OF PAVEMENT TYPES                                          HPM 1604
C                                                                       HPM 1605
      IF(HG5(I,J,K).LT.3.65) IA1(N,I,J)=IA1(N,I,J)+N1                   HPM 1606
      IF(HG5(I,J,K).GT.3.65.AND.HG5(I,J,K).LE.4.0) IA2(N,I,J)=IA2(N,I,J)HPM 1607
     A+N1                                                               HPM 1608
      IF(HG5(I,J,K).GT.4.0) IA3(N,I,J)=IA3(N,I,J)+N1                    HPM 1609
C                                                                       HPM 1610
C **** PERC. OF PAVEMENT CONDITIONS                                     HPM 1611
C                                                                       HPM 1612
      BOG=2.                                                            HPM 1613
      IF(I.EQ.1.AND.J.LE.2) BOG=2.5                                     HPM 1614
      IF(I.GT.1.AND.J.LE.3) BOG=2.5                                     HPM 1615
      IF(HG6(I,J,K).LT.BOG) IB1(N,I,J)=IB1(N,I,J)+N1                    HPM 1616
      IF(HG6(I,J,K).GE.BOG.AND.HG6(I,J,K).LT.3.4) IB2(N,I,J)=IB2(N,I,J  HPM 1617
     A)+N1                                                              HPM 1618
      IF(HG6(I,J,K).GE.3.4) IB3(N,I,J)=IB3(N,I,J)+N1                    HPM 1619
C                                                                       HPM 1620
C **** V/C RATIOS                                                       HPM 1621
C                                                                       HPM 1622
      BPG=.8                                                            HPM 1623
      IF(I.NE.1) BPG=.9                                                 HPM 1624
      IF(HG3(I,J,K).LT.0.31) IC1(N,I,J)=IC1(N,I,J)+N1                   HPM 1625
      IF(HG3(I,J,K).GE.0.31.AND.HG3(I,J,K).LT.BPG) IC2(N,I,J)=IC2(N,I,  HPM 1626
     AJ)+N1                                                             HPM 1627
      IF(HG3(I,J,K).GE.BPG) IC3(N,I,J)=IC3(N,I,J)+N1                    HPM 1628
C                                                                       HPM 1629
C **** LANE WIDTHS                                                      HPM 1630
C                                                                       HPM 1631
      IF(HG4(I,J,K).LT.10.) ID1(N,I,J)=ID1(N,I,J)+N1                    HPM 1632
      IF(HG4(I,J,K).GE.10.0.AND.HG4(I,J,K).LE.11.) ID2(N,I,J)=ID2(N,I,  HPM 1633
     AJ)+N1                                                             HPM 1634
      IF(HG4(I,J,K).GT.11.) ID3(N,I,J)=ID3(N,I,J)+N1                    HPM 1635
 1984 CONTINUE                                                          HPM 1636
C                                                                       HPM 1637
C **** APPLICATION OF WEIGHTING FACTORS                                 HPM 1638
C                                                                       HPM 1639
      DO 1986 I=1,3                                                     HPM 1640
      DO 1986 J=1,5                                                     HPM 1641
      IF(N.EQ.2) IFAM(I,J)=IFIX(FLOAT(IFAM(I,J))/5.)                    HPM 1642
      IF(N.EQ.2) KFAM(KFK,I,J)=KFAM(KFK,I,J)+IFAM(I,J)                  HPM 1643
      ARK=FLOAT(ML1(I,J))                                               HPM 1644
      IF(N.EQ.2) ARK=HK(I,J)*1000.                                      HPM 1645
      IA1(N,I,J)=IFIX((FLOAT(IA1(N,I,J))/ARK*100.)+.5)                  HPM 1646
      IA2(N,I,J)=IFIX((FLOAT(IA2(N,I,J))/ARK*100.)+.5)                  HPM 1647
      IA3(N,I,J)=IFIX((FLOAT(IA3(N,I,J))/ARK*100.)+.5)                  HPM 1648
      IB1(N,I,J)=IFIX((FLOAT(IB1(N,I,J))/ARK*100.)+.5)                  HPM 1649
      IB2(N,I,J)=IFIX((FLOAT(IB2(N,I,J))/ARK*100.)+.5)                  HPM 1650
      IB3(N,I,J)=IFIX((FLOAT(IB3(N,I,J))/ARK*100.)+.5)                  HPM 1651
      IC1(N,I,J)=IFIX((FLOAT(IC1(N,I,J))/ARK*100.)+.5)                  HPM 1652
      IC2(N,I,J)=IFIX((FLOAT(IC2(N,I,J))/ARK*100.)+.5)                  HPM 1653
      IC3(N,I,J)=IFIX((FLOAT(IC3(N,I,J))/ARK*100.)+.5)                  HPM 1654
      ID1(N,I,J)=IFIX((FLOAT(ID1(N,I,J))/ARK*100.)+.5)                  HPM 1655
      ID2(N,I,J)=IFIX((FLOAT(ID2(N,I,J))/ARK*100.)+.5)                  HPM 1656
      ID3(N,I,J)=IFIX((FLOAT(ID3(N,I,J))/ARK*100.)+.5)                  HPM 1657
 1986 CONTINUE                                                          HPM 1658
      IF(N.EQ.2) GO TO 4056                                             HPM 1659
      N=2                                                               HPM 1660
      GO TO 1985                                                        HPM 1661
C                                                                       HPM 1662
C **** AVERAGING VARIABLES                                              HPM 1663
C                                                                       HPM 1664
 4056 IK=0                                                              HPM 1665
      I37=1                                                             HPM 1666
 4055 DO 4050 N=1,2                                                     HPM 1667
      DO 4050 I=1,3                                                     HPM 1668
      DO 4050 J=1,5                                                     HPM 1669
      IK=IK+1                                                           HPM 1670
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      GO TO(20,21,22,23,24,25,26,27,28,29,30,31) I37                    HPM 1671
   20 KBEL(KFK,IK)=IA1(N,I,J)+KBEL(KFK,IK)                              HPM 1672
      GO TO 4050                                                        HPM 1673
   21 KBEL(KFK,IK)=IA2(N,I,J)+KBEL(KFK,IK)                              HPM 1674
      GO TO 4050                                                        HPM 1675
   22 KBEL(KFK,IK)=IA3(N,I,J)+KBEL(KFK,IK)                              HPM 1676
      GO TO 4050                                                        HPM 1677
   23 KBEL(KFK,IK)=IB1(N,I,J)+KBEL(KFK,IK)                              HPM 1678
      GO TO 4050                                                        HPM 1679
   24 KBEL(KFK,IK)=IB2(N,I,J)+KBEL(KFK,IK)                              HPM 1680
      GO TO 4050                                                        HPM 1681
   25 KBEL(KFK,IK)=IB3(N,I,J)+KBEL(KFK,IK)                              HPM 1682
      GO TO 4050                                                        HPM 1683
   26 KBEL(KFK,IK)=IC1(N,I,J)+KBEL(KFK,IK)                              HPM 1684
      GO TO 4050                                                        HPM 1685
   27 KBEL(KFK,IK)=IC2(N,I,J)+KBEL(KFK,IK)                              HPM 1686
      GO TO 4050                                                        HPM 1687
   28 KBEL(KFK,IK)=IC3(N,I,J)+KBEL(KFK,IK)                              HPM 1688
      GO TO 4050                                                        HPM 1689
   29 KBEL(KFK,IK)=ID1(N,I,J)+KBEL(KFK,IK)                              HPM 1690
      GO TO 4050                                                        HPM 1691
   30 KBEL(KFK,IK)=ID2(N,I,J)+KBEL(KFK,IK)                              HPM 1692
      GO TO 4050                                                        HPM 1693
   31 KBEL(KFK,IK)=ID3(N,I,J)+KBEL(KFK,IK)                              HPM 1694
 4050 CONTINUE                                                          HPM 1695
      I37=I37+1                                                         HPM 1696
      IF(I37.NE.13) GO TO 4055                                          HPM 1697
      IF(KSSF.EQ.1) GO TO 1991                                          HPM 1698
      IF(KSSF.EQ.2) GO TO 1987                                          HPM 1699
      GO TO 70                                                          HPM 1700
C                                                                       HPM 1701
C **** HEADING AND OUTPUT STATEMENTS                                    HPM 1702
C                                                                       HPM 1703
 1987 IK=0                                                              HPM 1704
      I37=1                                                             HPM 1705
 4065 DO 4060 N=1,2                                                     HPM 1706
      DO 4060 I=1,3                                                     HPM 1707
      DO 4060 J=1,5                                                     HPM 1708
      IK=IK+1                                                           HPM 1709
      GO TO(32,33,34,35,36,37,38,39,40,41,42,43) I37                    HPM 1710
   32 IA1(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1711
      GO TO 4060                                                        HPM 1712
   33 IA2(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1713
      GO TO 4060                                                        HPM 1714
   34 IA3(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1715
      GO TO 4060                                                        HPM 1716
   35 IB1(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1717
      GO TO 4060                                                        HPM 1718
   36 IB2(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1719
      GO TO 4060                                                        HPM 1720
   37 IB3(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1721
      GO TO 4060                                                        HPM 1722
   38 IC1(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1723
      GO TO 4060                                                        HPM 1724
   39 IC2(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1725
      GO TO 4060                                                        HPM 1726
   40 IC3(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1727
      GO TO 4060                                                        HPM 1728
   41 ID1(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1729
      GO TO 4060                                                        HPM 1730
   42 ID2(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1731
      GO TO 4060                                                        HPM 1732
   43 ID3(N,I,J)=KBEL(KFK,IK)/KCOW                                      HPM 1733
 4060 CONTINUE                                                          HPM 1734
      I37=I37+1                                                         HPM 1735
      IF(I37.NE.13) GO TO 4065                                          HPM 1736
      DO 1502 I=1,3                                                     HPM 1737
      DO 1502 J=1,5                                                     HPM 1738
 1502 IFAM(I,J)=KFAM(KFK,I,J)/KCOW                                      HPM 1739
      DO 1988 I=1,3                                                     HPM 1740
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      GO TO(7,8,9) I                                                    HPM 1741
 1989 BPG=.80                                                           HPM 1742
      IF(I.NE.1) BPG=.90                                                HPM 1743
      WRITE(6,101) ((IA3(N,I,K),N=1,2),K=1,5),((IA2(N,I,K),N=1,2),K=1,  HPM 1744
     A5),((IA1(N,I,K),N=1,2),K=1,5)                                     HPM 1745
  101 FORMAT(7X,'PAVEMENT TYPE:',/,9X,'HIGH',16X,5(I3,7X,I3,7X),/,9X,   HPM 1746
     A'INTERM',14X,5(I3,7X,I3,7X),/,9X,'LOW',17X,5(I3,7X,I3,7X),///)    HPM 1747
      WRITE(6,102) ((IB1(N,I,K),N=1,2),K=1,5),((IB2(N,I,K),N=1,2),K=1,  HPM 1748
     A5),((IB3(N,I,K),N=1,2),K=1,5)                                     HPM 1749
  102 FORMAT(7X,'PAVEMENT CONDITION:1/',/,9X,'POOR',16X,5(I3,7X,I3,7X),  HPM 1750
     A/,9X,'FAIR',16X,5(I3,7X,I3,7X),/,9X,'GOOD',16X,5(I3,7X,I3,7X),///)HPM 1751
      WRITE(6,103) ((IC1(N,I,K),N=1,2),K=1,5),BPG,((IC2(N,I,K),N=1,2),  HPM 1752
     AK=1,5),BPG,((IC3(N,I,K),N=1,2),K=1,5)                             HPM 1753
  103 FORMAT(7X,'VOL/CAP RATIOS:2/',/,9X,'< .31',15X,5(I3,7X,I3,7X),/,  HPM 1754
     A9X,'.31 - ',F3.2,11X,5(I3,7X,I3,7X),/,9X,'> ',F3.2,15X,5(I3,7X,   HPM 1755
     BI3,7X),///)                                                       HPM 1756
      WRITE(6,104) ((ID1(N,I,K),N=1,2),K=1,5),((ID2(N,I,K),N=1,2),K=1,  HPM 1757
     A5),((ID3(N,I,K),N=1,2),K=1,5)                                     HPM 1758
  104 FORMAT(7X,'LANE WIDTH (FT):',/,9X,'< 10',16X,5(I3,7X,I3,7X),/,9X,  HPM 1759
     A'10 - 11',13X,5(I3,7X,I3,7X),/,9X,'> 11',16X,5(I3,7X,I3,7X),///)  HPM 1760
      WRITE(6,105) (IFAM(I,K),K=1,5)                                    HPM 1761
  105 FORMAT(7X,'5 YEAR AVERAGE',/,7X,'ANNUAL CAPITAL      ',/,7X,       HPM 1762
     A'OUTLAYS:      ',/,7X,'(IN THOUSANDS) 3/',8X,4('$',I6,13X),'$',I6,  HPM 1763
     B////,7X,'1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR  HPM 1764
     C2.0 TO 3.4: GOOD - PSR>3.4.',/,7X,'2/ TRAVEL IS FOR PEAK HOUR. ONEHPM 1765
     D DIRECTION ONLY.',/,,7X,'3/ EXCLUDING STRUCTURE COSTS')           HPM 1766
 1988 CONTINUE                                                          HPM 1767
 1991 DO 851 I=1,3                                                      HPM 1768
      DO 851 J=1,5                                                      HPM 1769
  851 IFAM(I,J)=0                                                       HPM 1770
      GO TO 70                                                          HPM 1771
    7 WRITE(6,5000) NOY                                                 HPM 1772
 5000 FORMAT('1',1X,24('* '),I4,2X,'RURAL SUMMARY IN PERCENTS',24('* '),HPM 1773
     A/////,/,31X,'INTERSTATE',8X,'OTHER PRIN ART',6X,'MINOR ARTERIAL',  HPM 1774
     B5X,'MAJOR COLLECTOR',5X,'MINOR COLLECTOR',/,27X,5(1X,'MILES'      HPM 1775
     C,5X,'TRAVEL',3X),//)                                              HPM 1776
      GO TO 1989                                                        HPM 1777
    8 WRITE(6,5001) NOY                                                 HPM 1778
 5001 FORMAT('1',1X,24('* '),I4,2X,'URBAN SUMMARY IN PERCENTS',24('* ') HPM 1779
     A,/////,31X,'INTERSTATE',8X,'OTH FWY & EXPY',6X,'OTHER PRIN ART',  HPM 1780
     B,6X,'MINOR ARTERIAL',8X,'COLLECTOR',/,27X,5(1X,'MILES',5X,'TRAVEL'HPM 1781
     C,3X),//)                                                          HPM 1782
      GO TO 1989                                                        HPM 1783
    9 WRITE(6,5002) NOY                                                 HPM 1784
 5002 FORMAT('1',1X,23('* '),I4,2X,'SMALL URBAN SUMMARY IN PERCENTS',2  HPM 1785
     A3('* '),/////,31X,'INTERSTATE',8X,'OTH FWY & EXPY',6X,'OTHER PRIN HPM 1786
     BART',6X,'MINOR ARTERIAL',8X,'COLLECTOR',/,27X,5(1X,'MILES',5X,'TRAHPM 1787
     CVEL',3X),//)                                                      HPM 1788
      GO TO 1989                                                        HPM 1789
   70 MGFLAG=2                                                          HPM 1790
 2912 CONTINUE                                                          HPM 1791
  700 WRITE(6,1234)                                                     HPM 1792
 1234 FORMAT(10X,'THRESHOLD REQUIRES REVISION')                         HPM 1793
      C1=SMCON9(I,J)/FLOAT(ML1(I,J))                                    HPM 1794
      C2=DELCON(I,J)/FLOAT(ML1(I,J))                                    HPM 1795
      PRINT,SMCON9                                                      HPM 1796
      PRINT,DELCON                                                      HPM 1797
      PRINT,I,J,ML1(I,J)                                                HPM 1798
      PRINT,C1,C2                                                       HPM 1799
      SMCON9(I,J)=0.                                                    HPM 1800
      DELCON(I,J)=0.                                                    HPM 1801
      DO 91 K=1,ML1(I,J)                                                HPM 1802
      SMCON9(I,J)=SMCON9(I,J)+SMCI(I,J,K)                               HPM 1803
      DELCON(I,J)=DELCON(I,J)+DELCI(I,J,K)                              HPM 1804
   91 PRINT,SMCI(I,J,K),DELCI(I,J,K),K                                  HPM 1805
      PRINT,SMCON9(I,J),DELCON(I,J)                                     HPM 1806
      GO TO 1235                                                        HPM 1807
C                                                                       HPM 1808
C **** OUTPUT STATEMENTS                                                HPM 1809
C                                                                       HPM 1810
```

```
 2950 IF(NYEA.EQ.5) GO TO 2989                                          HPM 1811
      IF(NYEA.EQ.10) GO TO 2989                                         HPM 1812
      IF(NYEA.EQ.15) GO TO 2989                                         HPM 1813
      GO TO 710                                                         HPM 1814
 2989 MKN=0                                                             HPM 1815
  710 DO 720 I=1,3                                                      HPM 1816
      DO 720 J=1,5                                                      HPM 1817
      SM1(NYEA,I,J)=SMCON1(I,J)/HK(I,J)                                 HPM 1818
  720 TM1(NYEA,I,J)=SM1(NYEA,I,J)+TM1(NYEA,I,J)                         HPM 1819
      DO 900 J=1,5                                                      HPM 1820
      SM1(NYEA,2,J)=(SM1(NYEA,2,J)*HK1(2)+SM1(NYEA,3,J)*HK1(3))/        HPM 1821
     A(HK1(2)+HK1(3))                                                   HPM 1822
      TM1(NYEA,2,J)=SM1(NYEA,2,J)+TM2(NYEA,J)                           HPM 1823
  900 TM2(NYEA,J)=TM1(NYEA,2,J)                                         HPM 1824
      IF(NYEA.EQ.(NYEAR+1)) GO TO 727                                   HPM 1825
      GO TO 7281                                                        HPM 1826
  727 IF(KSSF.EQ.2) GO TO 728                                           HPM 1827
      GO TO 1235                                                        HPM 1828
  728 DO 729 N=2,NYEAR+1                                                HPM 1829
      DO 729 I=1,2                                                      HPM 1830
      DO 729 J=1,5                                                      HPM 1831
  729 SM1(N,I,J)=TM1(N,I,J)/KCOW                                        HPM 1832
      DO 752 I=1,2                                                      HPM 1833
      IF(I.EQ.2) GO TO 5                                                HPM 1834
      WRITE(6,1092)                                                     HPM 1835
 1092 FORMAT('1',1X,26('* '),'RURAL CONDITION INDICES',26('* '),/////,  HPM 1836
     A20X,92('-'),/,53X,'OTHER',12X,'MINOR',12X,'MAJOR',12X,'MINOR',/,  HPM 1837
     B20X,'YEAR',9X,'INTERSTATE',8X,'PRIN ART',10X,'ARTERIAL',8X,       HPM 1838
     C'COLLECTOR',8X,'COLLECTOR',/,20X,92('-'),/)                       HPM 1839
      GO TO 9091                                                        HPM 1840
    5 WRITE(6,1079)                                                     HPM 1841
 1079 FORMAT('1',1X,24('* '),'TOTAL URBAN CONDITION INDICES',24('* '),  HPM 1842
     A/////,20X,92('-'),/,52X,'OTH FWY',11X,'OTHER',12X,'MINOR',/,      HPM 1843
     B20X,'YEAR',9X,'INTERSTATE',9X,'& EXPWY',9X,'PRIN ART',8X,         HPM 1844
     C'ARTERIAL',9X,'COLLECTOR',/,20X,92('-'),/)                        HPM 1845
 9091 DO 721 NY=1,NYEAR                                                 HPM 1846
      NOY=1974+NY+1                                                     HPM 1847
      N=NY+1                                                            HPM 1848
      WRITE(6,1007) NOY,SM1(N,I,1),SM1(N,I,2),SM1(N,I,3),SM1(N,I,4),SM1 HPM 1849
     1(N,I,5)                                                           HPM 1850
 1007 FORMAT(20X,I4,5(12X,F5.2),/)                                      HPM 1851
  721 CONTINUE                                                          HPM 1852
      WRITE(6,1080)                                                     HPM 1853
 1080 FORMAT(20X,92('-'))                                               HPM 1854
  752 CONTINUE                                                          HPM 1855
      GO TO 508                                                         HPM 1856
C                                                                       HPM 1857
C **** OPTIONAL OUTPUT STATEMENTS                                       HPM 1858
C                                                                       HPM 1859
      DO 6250 I=1,3                                                     HPM 1860
      GO TO(6251,6252,6253) I                                           HPM 1861
 6251 WRITE(6,6280)                                                     HPM 1862
 6280 FORMAT('1',1X,16('* '),'PERCENT OF RURAL PAVEMENTS WITH PSR BELOW HPM 1863
     AMINIMUM TOLERABLE LEVELS',16('* '),/////,20X,92('-'),/,53X,       HPM 1864
     B'OTHER',12X,'MINOR',12X,'MAJOR',12X,'MINOR',/,20X,'YEAR',9X,      HPM 1865
     C'INTERSTATE',8X,'PRIN ART',10X,'ARTERIAL',8X,'COLLECTOR',         HPM 1866
     D8X,'COLLECTOR',/,20X,92('-'),/)                                   HPM 1867
      GO TO 6255                                                        HPM 1868
 6252 WRITE(6,6281)                                                     HPM 1869
 6281 FORMAT('1',1X,16('* '),'PERCENT OF URBAN PAVEMENTS WITH PSR BELOW HPM 1870
     AMINIMUM TOLERABLE LEVELS',16('* '),/////,20X,92('-'),/,52X,       HPM 1871
     B'OTH FWY',11X,'OTHER',12X,'MINOR',/,20X,'YEAR',9X,'INTERSTATE',   HPM 1872
     C9X,'& EXPWY',9X,'PRIN ART',8X,'ARTERIAL',9X,'COLLECTOR',/,        HPM 1873
     D20X,92('-'),/)                                                    HPM 1874
      GO TO 6255                                                        HPM 1875
 6253 WRITE(6,6282)                                                     HPM 1876
 6282 FORMAT('1',1X,15('* '),'PERCENT OF SMALL URBAN PAVEMENTS WITH PSR HPM 1877
     ABELOW MINIMUM TOLERABLE LEVELS',15('* '),/////,20X,92('-'),       HPM 1878
     B/,52X,'OTH FWY',11X,'OTHER',12X,'MINOR',/,20X,'YEAR',9X,          HPM 1879
     C'INTERSTATE',9X,'& EXPWY',9X,'PRIN ART',8X,'ARTERIAL',9X,         HPM 1880
```

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     D'COLLECTOR',/,20X,92('-'),/)                                          HPM 1881
6255 DO 6260 N=1,NYEAR                                                      HPM 1882
     DO 6260 K=1,5                                                          HPM 1883
6260 RPAD(N,I,K)=RPAD(N,I,K)/KCOW*100.                                      HPM 1884
     DO 6261 NY=1,NYEAR                                                     HPM 1885
     NOY=1975+NY                                                            HPM 1886
     WRITE(6,6262) NOY,(RPAD(NY,I,J),J=1,5)                                 HPM 1887
6262 FORMAT(20X,I4,5(12X,F5.2),/)                                           HPM 1888
6261 CONTINUE                                                               HPM 1889
     WRITE(6,6270)                                                          HPM 1890
6270 FORMAT(20X,92('-'))                                                    HPM 1891
6250 CONTINUE                                                               HPM 1892
 508 WRITE(6,507)                                                           HPM 1893
 507 FORMAT('1',1X,26('* '),'SUMMARY OF DISBURSEMENTS',1X,26('* '),////HPM 1894
    A/,19X,92('-'),/,37X,'ADMIN,MAIN',16X,'LOCAL',14X,'NON-LOCAL',11X,      HPM 1895
    B'PRICE',/,19X,'YEAR',15X,'& OTHER',14X,'CAPITAL OUTLAYS',5X,           HPM 1896
    C'CAPITAL OUTLAYS',7X,'DEFLATOR',/,19X,92('-'),/)                       HPM 1897
     AKER=1.                                                                HPM 1898
     DO 16 I=1,NYEAR                                                        HPM 1899
     AKER=AKER*(1.+WSIN(I)/100.)                                            HPM 1900
     NOY=1975+I                                                             HPM 1901
     NZ1=IFIX(FUND(I))                                                      HPM 1902
     NZ2=IFIX(TFUND1(I))                                                    HPM 1903
     NZ3=IFIX(ADMIN(I))                                                     HPM 1904
     WRITE(6,15) NOY,NZ1,NZ2,NZ3,AKER                                       HPM 1905
  15 FORMAT(19X,I4,16X,I6,18X,I6,15X,I6,14X,F4.2,/)                         HPM 1906
  16 CONTINUE                                                               HPM 1907
     WRITE(6,17)                                                            HPM 1908
  17 FORMAT(19X,92('-'))                                                    HPM 1909
1235 RETURN                                                                 HPM 1910
     END                                                                    HPM 1911
```

APPENDIX B

Sample HIPERFORM Output

(Scenario T-4)

* INDIANA POPULATION ESTIMATES *

YEAR	FEMALE	MALE	TOTAL
1976	2721213	2583408	5304622
1977	2724349	2585777	5310128
1978	2734861	2595147	5330011
1979	2753609	2612330	5365943
1980	2776940	2633871	5410811
1981	2794016	2650734	5444751
1982	2811092	2667597	5478691
1983	2828163	2684460	5512631
1984	2845244	2701323	5546571
1985	2862323	2718189	5580512
1986	2880076	2736110	5616187
1987	2897829	2754031	5651862
1988	2915582	2771952	5687537
1989	2933335	2789873	5723212
1990	2951091	2807798	5758889

* U.S. AUTO EFFICIENCY PROJECTIONS *

YEAR	NEW CAR SALES 1/	TOTAL NUMBER OF AUTOS 1/	FLEET MPG	PERSONS PER AUTO
1976	10100	98504	13.71	2.18
1977	11199	101289	14.08	2.14
1978	11300	103118	14.62	2.12
1979	10899	105360	15.23	2.09
1980	11399	108351	15.92	2.05
1981	11100	111043	16.70	2.02
1982	11000	113036	17.60	2.00
1983	11500	115311	18.61	1.98
1984	12000	118152	19.73	1.95
1985	12300	120979	20.92	1.92
1986	12300	123550	22.07	1.90
1987	12399	125942	23.06	1.88
1988	12500	128279	23.90	1.87
1989	12500	130483	24.62	1.85
1990	12500	132340	25.21	1.84

1/ IN THOUSANDS

* VMT PROJECTIONS *

YEAR	AUTO VMT 1/	COMBINATION VMT 1/	TOTAL VMT 1/	FLEET MPG
1976	29373	2126	38473	12.15
1977	30180	2168	39555	12.42
1978	31050	2275	40781	12.77
1979	31851	2319	41861	13.18
1980	32280	2434	42553	13.58
1981	33012	2503	43578	14.05
1982	33806	2513	44623	14.59
1983	34527	2642	45697	15.14
1984	35229	2752	46733	15.72
1985	35940	2821	47740	16.34
1986	36650	2877	48736	16.92
1987	37346	2932	49717	17.42
1988	38012	2996	50669	17.85
1989	38648	3057	51585	18.22
1990	39261	3115	52471	18.53

1/ IN MILLIONS OF VEHICLE MILES TRAVELED

* REGISTRATION PROJECTIONS *

YEAR	AUTO REGISTRATIONS	TRUCKS SINGLE UNIT REGISTRATIONS	TRUCKS COMBINATION REGISTRATIONS	TOTAL REGISTRATIONS	PERSONS PER VEHICLE
1976	2652311	719704	39958	3426833	1.55
1977	2713495	739988	41074	3509769	1.51
1978	2759177	756208	42186	3573046	1.49
1979	2803721	772258	43146	3634859	1.48
1980	2847795	788320	44475	3696578	1.46
1981	2882846	802013	45683	3746735	1.45
1982	2915602	815181	46704	3793873	1.44
1983	2946675	827938	48232	3839464	1.44
1984	2976460	840540	49781	3883525	1.43
1985	3005231	852908	51181	3926235	1.42
1986	3034119	865412	52572	3969189	1.41
1987	3062337	877828	54010	4011427	1.41
1988	3089993	890184	55562	4053157	1.40
1989	3117173	902504	57157	4094414	1.40
1990	3143945	914807	58779	4135271	1.39

* FUEL CONSUMPTION AND TON-MILE ESTIMATES *

YEAR	RETAIL GAS PRICE	MOTOR FUEL CONSUMPTION 1/	INTERCITY TON-MILES 2/
1976	.61	3185000	19270
1977	.64	3183000	19651
1978	.65	3193000	20621
1979	.68	3177000	21022
1980	.78	3133000	22061
1981	.83	3101000	22686
1982	.88	3057000	22777
1983	.92	3019000	23946
1984	.98	2972000	24949
1985	1.04	2921000	25567
1986	1.10	2879000	26074
1987	1.17	2853000	26581
1988	1.24	2838000	27159
1989	1.32	2831000	27710
1990	1.40	2831000	28234

1/ IN THOUSANDS OF GALLONS

2/ IN MILLIONS

* REVENUE PROJECTIONS 1/ *

YEAR	REGISTRATION REVENUES	FUEL TAX REVENUES	OTHER REVENUES	TOTAL REVENUES
1976	75447	245448	266821	587716
1977	77401	246768	269551	593720
1978	79024	247388	271437	597849
1979	80558	245914	271537	598009
1980	82253	401810	400271	884334
1981	83701	420413	416970	921084
1982	85018	438906	433218	957142
1983	86530	456433	448834	991797
1984	88027	479892	469291	1037210
1985	89438	503260	489409	1082107
1986	90852	527274	510433	1128559
1987	92276	554908	534232	1181416
1988	93740	586766	561519	1242025
1989	95220	622194	591741	1309155
1990	96705	660149	623913	1380767

1/ IN THOUSANDS OF DOLLARS

* 1980 RURAL SUMMARY IN PERCENTS* *

	INTERSTATE		OTHER PRIN ART		MINOR ARTERIAL		MAJOR COLLECTOR		MINOR COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	35	59	6	14
INTERM	0	0	0	0	0	0	49	34	36	41
LOW	0	0	0	0	0	0	16	6	58	44
PAVEMENT CONDITION: 1/										
POOR	1	1	2	2	2	1	15	16	28	27
FAIR	17	15	31	28	28	20	52	47	47	48
GOOD	82	84	65	70	70	78	32	35	24	25
VOL/CAP RATIOS: 2/										
< .31	17	10	41	44	37	29	65	52	61	56
.31 - .80	67	71	51	49	53	58	33	43	39	44
> .80	16	19	7	7	9	12	2	5	0	0
LANE WIDTH (FT):										
< 10	0	0	0	0	0	0	38	31	48	49
10 - 11	0	0	6	8	26	20	59	65	49	48
> 11	100	100	94	92	74	79	3	4	3	2
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$ 20622		$ 24488		$ 42533		$ 15466		$ 15466	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* 1980 URBAN SUMMARY IN PERCENTS* *

	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	100	100	87	94
INTERM	0	0	0	0	0	0	0	0	13	6
LOW	0	0	0	0	0	0	0	0	0	0
PAVEMENT CONDITION: 1/										
POOR	0	0	0	0	6	5	0	0	13	13
FAIR	10	12	10	4	36	34	52	51	46	43
GOOD	90	88	90	95	58	60	46	48	40	43
VOL/CAP RATIOS: 2/										
< .31	7	3	29	16	13	7	4	2	24	16
.31 - .90	61	51	67	78	28	21	41	31	69	75
> .90	32	45	5	6	58	71	54	67	6	8
LANE WIDTH (FT):										
< 10	0	0	0	0	9	6	4	4	27	25
10 - 11	0	0	5	4	24	27	56	55	49	49
> 11	100	100	95	96	67	67	39	40	24	25
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$ 46399		$ 18044		$ 30933		$ 14177		$ 7732	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* 1980 SMALL URBAN SUMMARY IN PERCENTS* * * * * * * * * * * * * * * * * * * *

	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	100	100	68	81
INTERM	0	0	0	0	0	0	0	0	28	17
LOW	0	0	0	0	0	0	0	0	4	1
PAVEMENT CONDITION: 1/										
POOR	0	0	2	3	8	8	13	11	13	13
FAIR	0	0	13	10	42	41	48	45	46	45
GOOD	100	100	84	87	49	50	39	43	40	41
VOL/CAP RATIOS: 2/										
< .31	0	0	42	45	10	6	23	19	52	50
.31 - .90	70	74	53	50	62	59	56	60	42	42
> .90	30	26	5	4	27	35	20	21	5	7
LANE WIDTH (FT):										
< 10	0	0	0	0	11	10	14	13	25	30
10 - 11	0	0	0	0	15	14	33	36	38	36
> 11	100	100	100	100	73	76	52	50	36	34
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$ 1288		$ 2577		$ 7732		$ 5155		$ 5155	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* 1985 RURAL SUMMARY IN PERCENTS* *

	INTERSTATE		OTHER PRIN ART		MINOR ARTERIAL		MAJOR COLLECTOR		MINOR COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	37	60	6	14
INTERM	0	0	0	0	0	0	47	33	41	45
LOW	0	0	0	0	0	0	16	6	53	39
PAVEMENT CONDITION: 1/										
POOR	4	2	5	3	4	2	25	24	30	31
FAIR	9	8	20	16	21	18	51	40	46	46
GOOD	87	89	74	80	74	80	24	36	23	23
VOL/CAP RATIOS: 2/										
< .31	12	7	23	28	17	12	38	30	33	29
.31 - .80	66	67	67	63	66	66	57	55	65	66
> .80	22	25	9	8	17	21	5	14	1	4
LANE WIDTH (FT):										
< 10	0	0	0	0	0	0	37	30	48	43
10 - 11	0	0	2	2	17	12	58	62	49	48
> 11	100	100	98	98	82	87	5	7	3	9
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$ 37266		$ 44253		$ 76862		$ 27949		$ 27949	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* 1985 URBAN SUMMARY IN PERCENTS* *

	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	100	100	87	94
INTERM	0	0	0	0	0	0	0	0	13	6
LOW	0	0	0	0	0	0	0	0	0	0
PAVEMENT CONDITION: 1/										
POOR	0	0	0	0	9	6	6	4	12	12
FAIR	3	2	12	7	37	33	72	68	59	56
GOOD	97	97	88	93	54	61	22	27	29	32
VOL/CAP RATIOS: 2/										
< .31	0	0	10	4	9	5	1	1	7	5
.31 - .90	66	50	71	69	31	24	39	29	76	73
> .90	34	50	19	26	59	70	59	70	16	21
LANE WIDTH (FT):										
< 10	0	0	0	0	9	6	3	3	26	24
10 - 11	0	0	5	4	21	23	54	53	47	47
> 11	100	100	95	96	70	71	42	44	26	29
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$ 83849		$ 32608		$ 55899		$ 25620		$ 13974	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* 1985 SMALL URBAN SUMMARY IN PERCENTS* * * * * * * * * * * * * * * * * * * *

	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	100	100	72	84
INTERM	0	0	0	0	0	0	0	0	24	15
LOW	0	0	0	0	0	0	0	0	3	1
PAVEMENT CONDITION: 1/										
POOR	0	0	0	0	12	11	13	12	10	10
FAIR	0	0	26	18	33	33	52	51	40	41
GOOD	100	100	73	81	55	56	34	36	50	47
VOL/CAP RATIOS: 2/										
< .31	0	0	11	8	5	3	15	12	28	26
.31 - .90	65	67	84	88	57	51	58	60	66	67
> .90	35	32	5	4	38	45	26	27	5	7
LANE WIDTH (FT):										
< 10	0	0	0	0	11	10	14	13	23	26
10 - 11	0	0	0	0	14	13	32	34	37	35
> 11	100	100	100	100	74	77	55	52	39	39
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$ 2328		$ 4657		$ 13974		$ 9316		$ 9318	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* 1990 RURAL SUMMARY IN PERCENTS* *

	INTERSTATE		OTHER PRIN ART		MINOR ARTERIAL		MAJOR COLLECTOR		MINOR COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	43	65	6	15
INTERM	0	0	0	0	0	0	42	28	41	45
LOW	0	0	0	0	0	0	15	6	52	39
PAVEMENT CONDITION: 1/										
POOR	2	1	1	1	3	2	32	26	32	35
FAIR	5	4	27	25	18	14	38	39	42	38
GOOD	92	94	71	73	78	84	29	35	25	26
VOL/CAP RATIOS: 2/										
< .31	0	0	6	7	4	3	16	12	9	9
.31 - .80	73	70	81	82	69	62	77	71	88	84
> .80	26	30	12	10	26	34	6	17	2	7
LANE WIDTH (FT):										
< 10	0	0	0	0	0	0	37	30	48	49
10 - 11	0	0	1	1	12	8	58	62	48	46
> 11	100	100	99	99	87	91	5	7	3	4
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$ 49080		$ 58283		$101229		$ 36810		$ 36810	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* 1990 URBAN SUMMARY IN PERCENTS* *

	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	100	100	89	95
INTERM	0	0	0	0	0	0	0	0	10	4
LOW	0	0	0	0	0	0	0	0	0	0
PAVEMENT CONDITION: 1/										
POOR	0	0	0	0	11	9	10	8	20	15
FAIR	1	1	12	6	41	37	80	80	45	47
GOOD	98	99	88	94	47	53	10	12	34	37
VOL/CAP RATIOS: 2/										
< .31	0	0	0	0	2	1	0	0	3	2
.31 - .90	60	44	81	73	34	24	35	25	77	72
> .90	40	56	19	26	63	74	64	74	19	25
LANE WIDTH (FT):										
< 10	0	0	0	0	9	6	3	3	25	23
10 - 11	0	0	2	2	18	20	52	49	47	47
> 11	100	100	97	98	72	74	44	47	27	29
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$110431		$ 42945		$ 73621		$ 33742		$ 18405	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR. ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* 1990 SMALL URBAN SUMMARY IN PERCENTS* * * * * * * * * * * * * * * * * * * *

	INTERSTATE		OTH FWY & EXPY		OTHER PRIN ART		MINOR ARTERIAL		COLLECTOR	
	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL	MILES	TRAVEL
PAVEMENT TYPE:										
HIGH	100	100	100	100	100	100	100	100	76	86
INTERM	0	0	0	0	0	0	0	0	21	12
LOW	0	0	0	0	0	0	0	0	2	0
PAVEMENT CONDITION: 1/										
POOR	0	0	11	6	18	14	15	13	11	12
FAIR	0	0	10	10	37	39	54	54	38	39
GOOD	100	100	78	84	44	46	31	32	51	49
VOL/CAP RATIOS: 2/										
< .31	0	0	5	3	1	1	5	4	9	10
.31 - .90	50	55	84	90	56	50	63	62	81	78
> .90	50	45	11	7	42	49	31	34	9	12
LANE WIDTH (FT):										
< 10	0	0	0	0	11	10	13	12	21	24
10 - 11	0	0	0	0	14	13	32	34	34	32
> 11	100	100	100	100	74	77	55	53	44	44
5 YEAR AVERAGE ANNUAL CAPITAL OUTLAYS: (IN THOUSANDS) 3/	$ 3067		$ 6134		$ 18405		$ 12270		$ 12270	

1/ POOR - PSR <2.0 (<2.5 PRINCIPAL ARTERIAL): FAIR - PSR 2.0 TO 3.4: GOOD - PSR>3.4.
2/ TRAVEL IS FOR PEAK HOUR, ONE DIRECTION ONLY.
3/ EXCLUDING STRUCTURE COSTS

* RURAL CONDITION INDICES* *

YEAR	INTERSTATE	OTHER PRIN ART	MINOR ARTERIAL	MAJOR COLLECTOR	MINOR COLLECTOR
1976	80.38	80.69	75.24	56.13	54.41
1977	80.44	81.18	75.53	56.28	53.49
1978	80.24	81.60	75.56	55.19	52.81
1979	79.69	81.57	74.99	57.90	51.18
1980	80.19	82.18	75.83	56.91	50.35
1981	80.40	82.79	76.07	56.99	49.56
1982	79.98	82.98	76.41	55.48	49.03
1983	79.40	82.69	76.12	55.33	48.13
1984	79.05	82.96	76.09	55.10	47.86
1985	78.36	82.80	75.45	54.24	47.62
1986	78.29	82.75	75.09	54.80	46.57
1987	78.15	82.06	74.72	53.63	46.06
1988	77.66	81.64	74.15	52.79	45.82
1989	76.94	81.83	74.64	51.98	45.46
1990	76.95	82.12	74.38	51.39	44.78

* TOTAL URBAN CONDITION INDICES* *

YEAR	INTERSTATE	OTH FWY & EXPWY	OTHER PRIN ART	MINOR ARTERIAL	COLLECTOR
1976	70.08	81.25	55.32	58.83	63.04
1977	70.16	80.02	54.96	57.78	62.41
1978	69.65	79.21	54.28	57.15	62.07
1979	69.69	78.61	54.30	56.53	61.74
1980	69.53	78.23	54.31	55.82	60.90
1981	69.74	78.32	54.33	55.43	60.42
1982	69.20	77.53	54.25	54.63	59.66
1983	69.19	76.16	53.92	53.77	58.97
1984	68.95	75.89	53.47	53.62	58.97
1985	68.52	76.13	53.00	52.66	58.74
1986	68.31	75.20	52.63	51.70	59.03
1987	67.94	74.36	52.25	51.26	58.39
1988	67.44	74.28	51.94	50.53	58.73
1989	66.78	73.61	51.54	49.79	57.74
1990	66.97	73.51	51.47	49.67	56.52

* SUMMARY OF DISBURSEMENTS *

YEAR	ADMIN, MAIN & OTHER	LOCAL CAPITAL OUTLAYS	NON-LOCAL CAPITAL OUTLAYS	PRICE DEFLATOR
1976	246785	115638	234780	1.07
1977	251413	117230	238014	1.15
1978	256252	106751	216738	1.23
1979	261057	110232	223804	1.33
1980	266082	204022	414228	1.43
1981	271737	214284	435062	1.55
1982	276900	224479	455762	1.67
1983	281884	234271	475641	1.79
1984	286746	247652	502810	1.91
1985	291406	260931	529769	2.04
1986	295996	274745	557817	2.16
1987	300584	290674	590157	2.30
1988	305168	309162	627694	2.44
1989	309821	329779	669553	2.59
1990	314546	351852	714367	2.75

COVER DESIGN BY ALDO GIORGINI